

AVIONICS SYSTEMS LABORATORY/
BUILDING 16

HISTORICAL DOCUMENTATION

Prepared for:
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

Prepared by:
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PREFACE

In response to President George W. Bush's announcement in January 2004 that the Space Shuttle Program (SSP) would end in 2010, the National Aeronautics and Space Administration (NASA) completed a nation-wide historical survey and evaluation of NASA-owned facilities and properties (real property assets) at all its Centers and component facilities. The buildings and structures which supported the SSP were inventoried and assessed as per the criteria of eligibility for listing in the National Register of Historic Places (NRHP) in the context of this program. This study was performed in compliance with Section 110 of the National Historic Preservation Act (NHPA) of 1966 (Public Law 89-665), as amended; the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190); Executive Order (EO) 11593: Protection and Enhancement of the Cultural Environment; EO 13287, Preserve America, and other relevant legislation.

As part of this nation-wide study, in September 2006, historical survey and evaluation of NASA-owned and managed facilities at was conducted by NASA's Lyndon B. Johnson Space Center (JSC) in Houston, Texas. The results of this study are presented in a report entitled, "Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program, Lyndon B. Johnson Space Center, Houston, Texas," prepared in November 2007 by NASA JSC's contractor, Archaeological Consultants, Inc. As a result of this survey, the Avionics Systems Laboratory (Building 16) was determined eligible for listing in the NRHP, with concurrence by the Texas State Historic Preservation Officer (SHPO). The survey concluded that Building 5 is eligible for the NRHP under Criteria A and C in the context of the U.S. Space Shuttle program (1969-2010). Because it has achieved significance within the past 50 years, Criteria Consideration G applies.

At the time of this documentation, Building 16 was still used to support the SSP as an engineering research facility, which is also sometimes used for astronaut training. This documentation package precedes any undertaking as defined by Section 106 of the NHPA, as amended, and implemented in 36 CFR Part 800, as NASA JSC has decided to proactively pursue efforts to mitigate the potential adverse affects of any future modifications to the facility. It includes a historical summary of the Space Shuttle program; the history of JSC in relation to the SSP; a narrative of the history of Building 16 and how it supported the SSP; and a physical description of the structure. In addition, photographs documenting the construction and historical use of Building 16 in support of the SSP, as well as photographs of the facility documenting the existing conditions, special technological features, and engineering details, are included. A contact sheet printed on archival paper, and an electronic copy of the work product on CD, are also provided.

ACKNOWLEDGEMENTS

Archaeological Consultants, Inc. (ACI) of Sarasota, Florida extends their gratitude to Perri E. Fox, NASA JSC's Shuttle Transition Manager, and Sandra J. Tetley, NASA JSC's Real Property Officer and Historic Preservation Officer (HPO), for making all arrangements for access and information gathering in support of this documentation. We also thank the staff of the JSC Imagery Repository for their cooperation in providing historical photographs; and the staff of the Engineering Drawing Control Center for their cooperation in providing architectural drawings of the facility. We deeply appreciate the efforts of Gilbert Perez, Building 16 Facility Manager, for serving as ACI's point of contact at the facility; and Don Magnusson, Derrick Hart, and Lamar Gordon for providing valuable information on the use of the Shuttle Avionics Integration Laboratory in support of the Space Shuttle Program; Larry Detrick for his insight on the use of the Electrical Power Systems Laboratory in relation to the SSP; and Clint Clements and Amy Efting for their effort in explaining how the Systems Engineering Simulator Facility aided the SSP. Finally, we would like to thank Rebecca Wright and Jennifer Ross-Nazzal of Tessada & Associates, for conducting oral histories, which greatly enhanced our discussion of the buildings.

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AVIONICS SYSTEMS LABORATORY
BUILDING 16
JOHNSON SPACE CENTER,
HOUSTON, TEXAS

Basic Information

Location: At the end of Delta Link Road, to the southeast
Johnson Space Center
Houston
Harris County
Texas

U.S.G.S. 7.5. minute League City, Texas, quadrangle,
Universal Transverse Mercator coordinates:
15.297526.3271461

Date of Construction: 1962-1964

Architect/Engineer: The Lummus Company, Houston, Texas (Wings N and E); Brown & Root, Inc., Houston, Texas; Brooks & Barr, Austin, Texas; Harvin C. Moore, Houston, Texas; MacKie & Kamrath, Houston, Texas; and Wirtz, Calhoun, Tungate, & Jackson, Houston, Texas (Wing S)

Builder: C.H. Leavell and Company, El Paso, Texas; Morrison-Knudsen Company Inc., Boise, Idaho; and Paul Hardeman, Inc., Stanton, California

Present Owner: National Aeronautics and Space Administration
Johnson Space Center, Houston, Texas

Present Use: Provide integration and verification of Space Shuttle avionics and software.

Significance: The Avionics Systems Laboratory (Building 16) is considered eligible for listing in the National Register of Historic Places (NRHP) in the context of the U.S. Space Shuttle Program (1969-2010) under Criterion A in the area of Space Exploration and under Criterion C in the area of Engineering. Because it has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the facility is distinguished for providing the highest fidelity Shuttle simulations for all flight phases.

In the early developmental phase of the Space Shuttle Program, it played a key role in the testing and hardware and software certification for the first flight of each orbiter. The SAIL within Building 16 is a unique facility which continues to provide software verification in support of the Space Shuttle Program. Under Criterion C, the SAIL facility was specifically designed to test and evaluate Space Shuttle avionics systems, and contains one-of-a-kind test articles and simulators, including a full-scale replica of the orbiter's payload bay.

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The U.S. Space Shuttle Program

On January 5, 1972, President Nixon delivered a speech in which he outlined the end of the Apollo era and the future of a reusable space flight vehicle, the Space Shuttle, which would provide “routine access to space.” By commencing work at this time, Nixon added, “we can have the Shuttle in manned flight by 1978, and operational a short time after that.”¹ The Space Task Group (STG), previously established by President Nixon in February 1969, to recommend a future course for the U.S. Space Program, presented three choices of long-range plans. All included an Earth-orbiting space station, a space shuttle, and a manned Mars expedition.² Although none of the original programs presented was eventually selected, the National Aeronautics and Space Administration (NASA) implemented a program, shaped by the politics and economic realities of the time, which served as a first step toward any future plans for implementing a space station.³

On January 5, 1972, President Richard Nixon instructed NASA to proceed with the design and building of a partially reusable space shuttle consisting of a reusable orbiter, three reusable main engines, two reusable solid rocket boosters (SRBs), and one non-reusable external liquid fuel tank (ET). NASA’s administrators vowed that the shuttle would fly at least fifty times a year, making space travel economical and safe. NASA gave responsibility for developing the shuttle orbiter vehicle and overall management of the Space Shuttle Program (SSP) to the Manned Space Center (MSC, now the Johnson Space Center [JSC]) in Houston, based on the Center’s experience. The Marshall Space Flight Center (MSFC) in Huntsville, Alabama, was responsible for development of the Space Shuttle Main Engine (SSME), SRBs, the ET, and for all propulsion-related tasks. Engineering design support continued at MSC, MSFC and NASA’s Langley Research Center (LaRC), in Virginia, and engine tests were to be performed at NASA’s Mississippi National Space Technology Laboratories (NSTL, later named Stennis Space Center [SSC]) and at the Air Force’s Rocket Propulsion Laboratory in California, which later became the Santa Susana Field Laboratory (SSFL).⁴ NASA selected the Kennedy Space Center (KSC) in Florida, as the primary launch and landing site for the SSP. KSC, responsible for designing the launch and recovery facilities, was to develop methods for shuttle assembly, checkout, and launch operations.⁵

On September 17, 1976, the full-scale orbiter prototype, *Enterprise* (OV- 101), was completed. Designed for test purposes only and never intended for space flight, structural assembly of this

¹ Marcus Lindroos. “President Nixon’s 1972 Announcement on the Space Shuttle.” (NASA Office of Policy and Plans, NASA History Office, updated April 14, 2000).

² NASA, History Office, NASA Headquarters. “Report of the Space Task Group, 1969.”

³ Dennis R. Jenkins. *Space Shuttle, The History of the National Space Transportation System. The First 100 Missions*. (Cape Canaveral, Florida: Specialty Press, 2001), 99.

⁴ Jenkins, 122.

⁵ Linda Neuman Ezell. *NASA Historical Databook Volume III Programs and Projects 1969-1978*. The NASA History Series, NASA SP-4012, (Washington, D.C.: NASA History Office, 1988), Table 2-57; Ray A. Williamson. “Developing the Space Shuttle.” *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume IV: Accessing Space*. (Edited by John M. Logsdon. Washington, D.C.: U.S. Printing Office, 1999), 172-174.

orbiter had started more than two years earlier in June 1974 at Air Force Plant (AFP) 42 in Palmdale, California. Although the *Enterprise* was an aluminum shell prototype incapable of space flight, it reflected the overall design of the orbiter. As such, it served successfully in 1977 as the test article during the Approach and Landing Tests (ALT) aimed at checking out both the mating with the shuttle carrier aircraft (SCA) for ferry operations, as well as the orbiter's unpowered landing capabilities.

The first orbiter intended for space flight, *Columbia* (OV-102), arrived at KSC from the shuttle assembly facility in Palmdale in March 1979. Originally scheduled to lift off in late 1979, the launch date was delayed by problems with both the SSME components, as well as the thermal protection system (TPS). *Columbia* spent 610 days in the Orbiter Processing Facility (OPF), another thirty-five days in the Vehicle Assembly Building (VAB), and 105 days on Pad 39A before finally lifting off on April 12, 1981. STS-1, the first orbital test flight and first Space Shuttle Program mission, ended with a landing on April 14 at Edwards Air Force Base (AFB) in California. This launch demonstrated *Columbia's* ability to fly into orbit, conduct on-orbit operations, and return safely.⁶ *Columbia* flew three additional test flights in 1981 and 1982, all with a crew of two. The Orbital Flight Test Program ended in July 1982 with 95% of its objectives completed. After the end of the fourth mission, President Ronald Reagan declared that with the next flight the Shuttle would be "fully operational."

A total of 129 Space Shuttle missions have been launched from the KSC between April 1981 and December 2009. From April 1981 until the *Challenger* accident in January 1986, between two and nine missions were flown yearly, with an average of four to five per year. The milestone year was 1985, when nine flights were successfully completed. The years between 1992 and 1997 were the most productive, with seven or eight yearly missions. Since 1995, in addition to its unique responsibility as the shuttle launch site, KSC also became the preferred landing site.

Over the past two decades, the SSP has launched a number of planetary and astronomy missions including the Hubble Space Telescope (HST), the Galileo probe to Jupiter, Magellan to Venus, and the Upper Atmospheric Research Satellite. In addition to astronomy and military satellites, a series of Spacelab research missions were flown, which carried dozens of international experiments in disciplines ranging from materials science to plant biology. Spacelab was a manned, reusable, microgravity laboratory flown into space in the rear of the Space Shuttle cargo bay. It was developed on a modular basis allowing assembly in a dozen arrangements depending on the specific mission requirements.⁷ The first Spacelab mission, carried aboard *Columbia* (STS-9), began on November 28, 1983. Four Spacelab missions were flown between 1983 and 1985. Following a hiatus in the aftermath of the *Challenger* disaster, the next Spacelab mission was not launched until 1990. In total, twenty-four Space Shuttle missions carried Spacelab hardware before the program was decommissioned in 1998.⁸ In addition to astronomical,

⁶ Jenkins, 268.

⁷ NASA. *NASA Shuttle Reference Manual*. (1988).

⁸ STS-90, which landed on May 3, 1998, was the final Spacelab mission. NASA. "Shuttle Payloads and Related Information." *KSC Factoids*. Revised November 18, 2002.

atmospheric, microgravity, and life sciences missions, Spacelab was also used as a supply carrier to the HST and the Soviet space station *Mir*.

In 1995, a joint U.S./Russian Shuttle-*Mir* Program was initiated as a precursor to construction of the International Space Station (ISS). *Mir* had been launched in February 1986 and remained in orbit until March 2001.⁹ The first approach and flyaround of *Mir* took place on February 3, 1995 (STS-63); the first *Mir* docking was in June 1995 (STS-71). During the three-year Shuttle-*Mir* Program (June 27, 1995 to June 2, 1998) the Space Shuttle docked with *Mir* nine times. All but the last two of these docking missions used the Orbiter *Atlantis*. Many of the activities carried out were types they would perform on the ISS.¹⁰

On December 4, 1999, *Endeavour* (STS-88) launched the first component of the ISS into orbit. As noted by Williamson, this event marked, “at long last the start of the Shuttle’s use for which it was primarily designed – transport to and from a permanently inhabited orbital space station.”¹¹ STS-96, launched on May 27, 1999, marked the first mission to dock with the ISS. Since that time, most Space Shuttle missions have supported the continued assembly of the space station. As currently planned, ISS assembly missions will continue through the life of the Space Shuttle Program.

The SSP suffered two major setbacks with the tragic losses of the *Challenger* and *Columbia* on January 28, 1986, and February 1, 2003, respectively. Following the *Challenger* accident, the SSP was suspended, and President Ronald Reagan formed a thirteen-member commission to identify the cause of the disaster. The Rogers Commission report, issued on June 6, 1986, which also included a review of the SSP, concluded “that the drive to declare the Shuttle operational had put enormous pressures on the system and stretched its resources to the limit.”¹² In addition to mechanical failure, the Commission noted a number of NASA management failures that contributed to the catastrophe. As a result, among the tangible actions taken were extensive redesign of the SRBs; an upgrade of the Space Shuttle tires, brakes, and nose wheel steering mechanisms; the addition of a drag chute to help reduce speed upon landing; the addition of a crew escape system; and the requirement for astronauts to wear pressurized flight safety suits during launch and landing operations. Other changes involved reorganization and decentralization of the SSP. NASA moved the management of the program from JSC to NASA Headquarters, with the aim of preventing communication deficiencies.¹³ Experienced astronauts were placed in key NASA management positions, all documented waivers to existing flight safety criteria were revoked and forbidden, and a policy of open reviews was implemented.¹⁴ In addition, NASA adopted a Space Shuttle flight schedule with a reduced average number of launches, and discontinued the long-term practice of launching commercial and military

⁹ Tony Reichhardt (editor). *Space Shuttle, The First 20 Years*. (Washington, D.C.: Smithsonian Institution, 2002), 85.

¹⁰ Judy A. Rumerman, with Stephen J. Garber. *Chronology of Space Shuttle Flights 1981-2000*. HHR-70. (Washington, D.C.: NASA History Division, Office of Policy and Plans, October 2000), 3.

¹¹ Williamson, 191.

¹² Columbia Accident Investigation Board (CAIB). *Report Volume I*. (August 2003), 25.

¹³ CAIB, 101.

¹⁴ Cliff Lethbridge. “History of the Space Shuttle Program.” (2001), 4.

payloads.¹⁵ The launch of *Discovery* (STS-26) from KSC Pad 39B on September 29, 1988, marked a Return to Flight after a 32-month hiatus in manned spaceflight following the *Challenger* accident.

In the aftermath of the 2003 *Columbia* accident, a seven month investigation ensued, concluding with the findings of the Columbia Accident Investigation Board (CAIB), which determined that both technical and management conditions accounted for the loss of the orbiter and crew. According to the CAIB Report, the physical cause of the accident was a breach in the TPS on the leading edge of the left wing, caused by a piece of insulating foam, which separated from the ET after launch and struck the wing.¹⁶ NASA spent more than two years researching and implementing safety improvements for the orbiters, SRBs and ET. Following a two-year hiatus, the launch of STS-114 on July 26, 2005, marked the first Return to Flight since the loss of *Columbia*.

On January 14, 2004, President George W. Bush outlined a new space exploration initiative in a speech given at NASA Headquarters.

Today I announce a new plan to explore space and extend a human presence across our solar system . . . Our first goal is to complete the International Space Station by 2010 . . . The Shuttle's chief purpose over the next several years will be to help finish assembly of the International Space Station. In 2010, the Space Shuttle – after nearly 30 years of duty – will be retired from service...¹⁷

Following the President's speech, NASA released *The Vision for Space Exploration*, which outlined the Agency's approach to this new direction in space exploration.¹⁸ As part of this initiative, NASA will continue to use the Space Shuttle to complete assembly of the ISS. The Shuttle will not be upgraded to serve beyond 2010 and, after completing the ISS, the Space Shuttle Program will be retired.

¹⁵ Lethbridge, 5.

¹⁶ CAIB, 9.

¹⁷ The White House. "A Renewed Spirit of Discovery – The President's Vision for Space Exploration." (January 2004).

¹⁸ NASA Headquarters. "The Vision for Space Exploration." (February 2004).

Johnson Space Center

The Lyndon B. Johnson Space Center (JSC) officially opened on-site in June 1964 as the Manned Spacecraft Center (MSC).¹⁹ This approximately 1,620-acre facility is located near Clear Lake, Texas, about 25 miles from downtown Houston, in Harris County. Many of the approximate 140 buildings are specialized facilities devoted to spacecraft systems, materials research and development, and/or astronaut training. JSC also includes the Sonny Carter Training Facility, located roughly 4.5 miles to the northwest of JSC, close to Ellington Field. Opened in 1997, this facility is situated on land acquired through a lease/purchase agreement with the McDonnell Douglas Corporation. In addition, NASA JSC owns some of the facilities at Ellington Field, which are generally where the aircraft used for astronaut training are stored and maintained.

The origins of JSC can be traced to the summer of 1958 when three executives of the National Advisory Committee for Aeronautics (NACA), Dr. Hugh L. Dryden, Dr. Robert R. Gilruth, and Dr. Abe Silverstein, began to formulate a space program.²⁰ Almost immediately, Gilruth began to focus on manned spaceflight, and subsequently convened a group of his LaRC associates, who compiled the basics of what would become Project Mercury, the first U.S. manned space program. Eight days following the activation of NASA, with the approval of NASA's first administrator, Dr. T. Keith Glennan, the Space Task Group (STG) was created to implement this program. The group was formally established on November 3, 1958, with Gilruth named as Project Manager. The initial staff of the STG came from LaRC, but was soon supplemented with engineers from the Lewis Flight Propulsion Laboratory (now Glenn Research Center) and AVRO Aircraft, Ltd. of Canada.²¹

At first, the STG offices were located at LaRC. With the establishment of the Goddard Space Flight Center in Greensbelt, Maryland, in May 1959, plans were made to incorporate the STG into it, creating a new "space projects center."²² It was later decided to leave the STG at LaRC until the completion of Project Mercury; however, by January 1961, it was obvious that the STG would need to develop into an autonomous center, and on January 3, it was designated as such.²³ The May 25, 1961, announcement by President John F. Kennedy to send a man to the Moon by

¹⁹ Following the death of former President Lyndon B. Johnson, the U.S. Senate passed a resolution to rename the Manned Spacecraft Center in his memory. "MSC Is Renamed 'JSC'." *Roundup* (12, 8), March 2, 1973, 1; "Capacity Crowd View Dedication Ceremonies." *Roundup* (12, 20), August 31, 1973, 1 and 3. For ease of reference, JSC will be used throughout the text, with the exception of direct quotations from sources.

²⁰ Dryden was the Director of NACA; Gilruth was the head of the flight research section of NACA's Langley Aeronautical Laboratory (now Langley Research Center) in Hampton, Virginia; and Silverstein was the Director of NACA's Lewis Flight Propulsion Laboratory (now Glenn Research Center) in Cleveland, Ohio. As part of NASA's establishment, NACA, was deactivated and all of its personnel and facilities were transferred to NASA. James M. Grimwood. *Project Mercury: A Chronology*. (Washington, D.C.: NASA, Office of Scientific and Technical Information, 1963); Roger D. Launius. *NASA: A History of the U.S. Civil Space Program*. (Malabar, Fla.: Krieger Publishing Company, 2001), 29.

²¹ Grimwood; Loyd S. Swenson, Jr., James M. Grimwood and Charles C. Alexander. *This New Ocean: A History of Project Mercury*. (Washington, D.C.: NASA, Office of Technology Utilization, 1966), 153.

²² Swenson, et al., 115.

²³ Swenson, et al., 251.

the end of the decade reinforced the idea that the STG needed its independence, and soon. Thus, in August 1961, John Parsons, Associate Director of the Ames Research Center (ARC), was charged with establishing a survey team to locate a site for the new center.²⁴

On September 19, 1961, James Webb, NASA Administrator, announced that Houston, Texas, would be the site for NASA's new Center for manned spaceflight.²⁵ Numerous factors influenced the choice of Houston as the home of the new Center. First of all, Rice University was willing to donate 1000 acres of land for the Center. Additionally, Houston met all of the requirements set forth in the selection criteria. For example, Ellington Air Force Base was located nearby, as were Clear Lake and Galveston Bay; these facilities could support air and barge traffic, respectively. Houston also has a year-round moderate climate, and both Rice University and the University of Houston were in close proximity to the new site.²⁶

On November 1, 1961, the STG officially became the "Manned Spacecraft Center," with Gilruth as its first Director.²⁷ The first JSC employees officially transferred to Houston from LaRC were Ed Campagna of the Facilities Division, John Powers, from Public Affairs, and Martin Byrnes, Site Manager; their first offices were two vacant dress shops in the Gulfgate Shopping Center, which were donated by its site manager, Marvin Kaplan.²⁸ The trio was assigned the responsibilities of procuring temporary office space, hiring new personnel, and meeting with local organizations to help facilitate the needs of those co-workers who would soon be joining them.²⁹ From November 1961 until April 1962, nearly 400 additional employees were transferred from LaRC to Houston; the new Center officially became operational in Houston on March 1, 1962, when Gilruth moved the JSC's headquarters there.³⁰

To supplement the 1000 acres of land promised by Rice University, NASA purchased an additional 620 acres, mainly to provide highway access for the estimated 4000 employees.³¹ In

²⁴ Swenson, et al., 363-364.

²⁵ Glennan resigned effective January 22, 1961 when President Eisenhower left office. Webb was sworn into office on February 15, 1961. Grimwood.

²⁶ From a political viewpoint, Houston was located within the district of U.S. House Representative, Albert Thomas, chairman of the House Appropriations Committee, and Texas was the home state of Vice President Lyndon B. Johnson. Dr. Robert Gilruth Oral History Interview, February 27, 1987, 273-275, *The Glennan-Webb-Seamans Project*, National Air and Space Museum.

²⁷ "STG Renamed; Will Move." *Space News Roundup* (1, 1), November 1, 1961, 1.

²⁸ Martin A. Byrnes, Jr., interview by Robert Merrifield, December 12, 1967, (Houston, TX, Archives Department, Lyndon B. Johnson Space Center), 6.

²⁹ Temporary offices were located in buildings throughout the Houston area, including the Phil Rich Building, the Farnsworth-Chambers Building, the Lane-Wells Building, the Canada Dry Bottling Building, and a Veterans Administration Building; and at Ellington Field. "Houston Site Offices Move to Rich Building." *Space News Roundup* (1, 3), November 29, 1961, 1; "Move To Houston Area Is On Schedule." *Space News Roundup* (1, 6), January 10, 1962, 1; "Photo Captions." *Space News Roundup* (1, 18), June 27, 1962, 2.

³⁰ Henry C. Dethloff. *Suddenly, Tomorrow Came...A History of the Johnson Space Center*. (Houston: Lyndon B. Johnson Space Center, 1993), 48.

³¹ "Interview with I. Edward Campagna, Assistant Chief, Technical Services Division, Maintenance and Operations." August 24, 1967, Box MERR1, Oral History Series. Johnson Space Center History Collection, University of Houston-Clear Lake; Dethloff, 48.

September 1961, the Fort Worth Division of the U.S. Army Corps of Engineers (ACOE), under District Engineer, Colonel R. Paul West, was designated the construction agency for the new Center. Their first task was to hire an architecture/engineering (A/E) team to complete the initial design work for the new Center. Twenty teams were considered for the initial contract, and after three rounds of reviews and cuts, an A/E team headed by Brown & Root, Inc., of Houston, Texas, was selected. Partnered with them were master planners Charles Luckman Associates, Los Angeles, California; and the architectural firms of Brooks & Barr, Austin, Texas; Harvin C. Moore, Houston, Texas; MacKie & Kamrath, Houston, Texas; and Wirtz, Calhoun, Tungate, & Jackson, Houston, Texas.³² The nearly \$1.5 million contract was officially awarded in December 1961, and included general site development; master planning; design of the flight project facility, the engineering evaluation laboratory and the flight operations facility; and various site utilities.³³

Charles Luckman Associates developed the master plan of the JSC, and “did an outstanding job of meeting the functional requirements that had been set forth in developing a campus-like atmosphere for the facility.”³⁴ The central “quad” area, bounded by 2nd Street on the west, Avenue D on the south, 5th Street on the east, and Avenue C on the north, included three “lagoons” surrounded by small, man-made hills, as well as various walkways, trees, and shrubs.³⁵ Luckman Associates also advocated the use of a modular design system for the buildings with materials that could be manufactured off-site, which aided in the tight schedule for completion. Most of the buildings incorporated a poured concrete foundation, and skeletal steel walls faced with precast exposed aggregate facing (PEAF) panels. This allowed for the fabrication of the steel components while the foundation was being poured, and subsequently the manufacture of the PEAf panels while the steel skeleton was being erected.³⁶

Initial construction of the JSC was completed in three main phases. The contract for the first phase, preliminary site development, was awarded on March 29, 1962, to a joint venture of Morrison-Knudsen Construction Company of Boise, Idaho, and Paul Hardeman of Stanton, California; it amounted to \$3,673,000. They began the work in early April; it was completed on July 18, 1963.³⁷ The task included “overall site grading and drainage, utility installations including an electrical power system, a complete water supply and distribution system, sanitary and storm drainage systems, basic roads, security fence and street lighting.”³⁸

The invitations to bid for the Phase II contract of the construction, which was the first to include actual buildings, were distributed in early July 1962. At first, the task included an office

³² “Photo Captions.” *Space News Roundup* (1, 12), April 4, 1962, 2.

³³ “Design Work Contract Is Let For Clear Lake.” *Space News Roundup* (1, 5), December 27, 1961, 8.

³⁴ “Interview with James L. Ballard, Jr.” August 1, 1968, Box MERR1, Oral History Series. Johnson Space Center History Collection, University of Houston-Clear Lake.

³⁵ Campagna, August 24, 1967.

³⁶ Ballard, August 1, 1968; Campagna, August 24, 1967.

³⁷ “First Construction Contract Work Underway at Clear Lake.” *Space News Roundup* (1, 13), April 18, 1962, 1; “Clear Lake Site Commitment Now Stands At \$38,911,458.” *Space News Roundup* (3, 4), December 11, 1963, 3.

³⁸ “Interview with Jack P. Shields.” August 1, 1968, Box MERR4, Oral History Series. Johnson Space Center History Collection, University of Houston-Clear Lake; “First Construction Contract Work.”

building, a shop building and warehouse, a garage, a central heating and cooling plant, a fire station, and a sewage disposal plant, as well as all necessary paving and utilities for these structures.³⁹ By the time bids were received and opened, the statement of work had been revised to exclude the office building, the shop building, and the warehouse, all of which were replaced by the Data Processing Center (Building 12). By the time the contract was let in October 1962, the task had changed a second time. In the end, the ACOE signed a contract with the joint venture of W.S. Bellows Construction Corporation and Peter Kiewit & Sons Corporation, both of Houston, in the amount of \$4,145,044, for the construction of Building 12, the sewage disposal plant, the central heating and cooling plant, the fire station, and a water treatment plant and associated building.⁴⁰ Of these facilities, the fire station was the first to be completed in September 1963; the central heating and cooling plant was last, finished in December 1963.⁴¹

Phase III of JSC's construction incorporated the largest grouping of buildings under one contract. The invitations to bid on this phase were issued on September 25, 1962, and listed ten buildings with an approximate total area of 760,000 square feet.⁴² Similar to Phase II, the statement of work was revised prior to the submittal of the bids to include eleven office and lab buildings, and the temperature and humidity control machinery for the entire site. Interested firms were also asked to submit alternate proposals that incorporated additional facilities, which NASA was hoping to add to the contract if funding became available.⁴³ On December 3, 1962, Colonel Francis P. Koish, the new ACOE District Engineer, signed the official contract, which amounted to roughly \$19 million, with the joint venture of C.H. Leavell and Company of El Paso, Texas, Morrison-Knudsen Construction Company, and Paul Hardeman. Eleven major facilities were part of this contract, including the project management building, the cafeteria, the flight operations and astronaut training facility, the crew systems laboratory, the technical services office and shop buildings, the systems evaluation laboratory, a spacecraft research lab and office building, and a data acquisition building. Funding for the additional facilities had become available by this time, so additional support buildings, such as the shop building and warehouse, were also included. Per the contract, the buildings were to be ready for occupancy in 450 calendar days.⁴⁴

In October 1963, the Logistics Division became the first to move into its complete facility, the Support Office (Building 419) and its shops and warehouse (Building 420). By the end of 1963,

³⁹ "Second Major Clear Lake Building Contract Awarded." *Space News Roundup* (1, 17), June 13, 1962, 8.

⁴⁰ "Bids Open On Phase Two Of Clear Lake Work." *Space News Roundup* (1, 23), September 5, 1962, 1; "Phase II Contract Goes to Bellows, Peter Kiewit, Sons." *Space News Roundup* (1, 25), October 3, 1962, 8; Shields, August 1, 1968.

⁴¹ "Photo Captions." *Space News Roundup* (2, 23), September 4, 1963, 3; "Central Heating and Cooling Plant Completed." *Space News Roundup* (3, 5), December 25, 1963, 8.

⁴² "First Building Contract To Be Let In November." *Space News Roundup* (1, 20), July 25, 1962, 8.

⁴³ "Bids Open On Phase 3 Of Center Construction." *Space News Roundup* (2, 2), November 11, 1962, 1-2.

⁴⁴ "19 Million Dollar Construction Contract Signed." *Space News Roundup* (2, 4), December 12, 1962, 1; "MSC 'Site' Three-Fourths Complete, First Move Scheduled Next Month." *Space News Roundup* (2, 24), September 18, 1963, 1; Shields, August 1, 1968.

twelve additional buildings were certified as operational.⁴⁵ The major relocation to the new Center occurred between February and April 1964, and included the occupation of facilities such as the Auditorium and Public Affairs Building (Building 1), the Flight Crew Operations Office (Building 4), the Flight Crew Operations Lab (Building 7), the Systems Evaluation Lab (Building 13), and the Spacecraft Technical Lab (Building 16). The Director's office officially moved on March 6, 1964. During May, the Instrument and Electronics Lab (Building 15) was occupied, followed by the Manned Spaceflight Control Center, Houston (Building 30) at the end of June, when all leases on the temporary facilities expired.⁴⁶

Since its beginnings as the STG, JSC has had four main tasks with regard to manned spaceflight: spacecraft development; mission control; research and development; and astronaut selection and training.⁴⁷ The basic design guidelines for each space vehicle used during the Mercury, Gemini, Apollo, and Space Shuttle programs were developed by JSC engineers. JSC subsequently managed the contracts with private firms for spacecraft manufacture. It was also the responsibility of JSC engineers to develop the proper interfacing between the spacecraft and its respective launch vehicle, which was developed separately by NASA's MSFC (Mercury-Redstone, Apollo-Saturn, Shuttle SRBs, ET, and SSMEs) or the U.S. Air Force (Mercury-Atlas, Gemini-Titan).⁴⁸

In addition to spacecraft development and astronaut training, JSC is also responsible for mission control. Mission control begins once the space vehicle has cleared the launch pad, and ends when the vehicle lands.⁴⁹ The key figure of mission control is the Flight Director, who makes all final decisions with regards to the proceedings. All communication between the ground and the spacecraft is coordinated through the Spacecraft Communicator. The mission control team also includes personnel who monitor all aspects of the space vehicle, such as flight dynamics, communications links, data processing, and instrumentation. Between missions, the controllers plan for the next flight, conduct various in-house training exercises, and aid with astronaut training.⁵⁰

In conjunction with vehicle design, JSC has historically conducted related research and development, which generally falls into four categories: materials, electrical systems, life

⁴⁵ "MSC 'Site' Three-Fourths Complete;" "Major Move To Clear Lake Begins February 20." *Space News Roundup* (3, 6), January 8, 1964, 1.

⁴⁶ "Majority of MSC Personnel Relocated At New Site." *Space News Roundup* (3, 11), March 18, 1964, 2; "Final Relocation Of Center Employees Begins Today." *Space News Roundup* (3, 18), June 24, 1964, 1.

⁴⁷ "Gilruth Cites MSC Progress Despite Difficult Relocation." *Space News Roundup* (1, 19), July 11, 1962, 1.

⁴⁸ Archaeological Consultants, Inc. (ACI). *Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program. Lyndon B. Johnson Space Center, Houston, Texas.* November 2007, Section 4.3.1.

⁴⁹ Likewise, those who designed the launch vehicle generally handled the actual launch process. It should be noted that the Kennedy Space Center, which has conducted all launches for Apollo and Space Shuttle, grew from MSFC's Launch Operations Directorate, which controlled the initial Mercury-Redstone launches.

⁵⁰ All Mercury missions and the first four Gemini missions were controlled from the old Mercury Control Center at Cape Canaveral, Florida. The Mission Control Center at Houston took over starting with Gemini IV. ACI, Section 4.3.3.

systems, and life sciences. The materials category includes development and testing of active thermal control systems as well as spacecraft structure testing. Electrical systems includes testing of the various interfaces with spacecraft hardware and software, ensuring there are no anomalies within the wiring and electronics systems, and confirming the ability of the spacecraft's communications systems to connect to relay satellites and ground stations. Life systems and life sciences are inherently connected to one another and include the astronauts' spacesuits and backpacks, as well as ensuring that their meals meet nutritional guidelines, taste good and store well.⁵¹

The last major task of JSC, and probably the most well-known besides mission control, is astronaut selection and training. From the original "Mercury 7," JSC has determined the criteria for astronaut selection and handled all interviews and examinations during the selection procedure. Additionally, the Center has established all training curricula, which provide astronauts with the basic knowledge needed to fly a mission and survive in emergency circumstances, as well as more specific training for tasks associated with a particular mission. Since Project Gemini, program-specific spacecraft simulators and trainers have been located within various buildings at JSC for astronaut training.⁵²

⁵¹ ACI, Section 4.3.4.

⁵² ACI, Section 4.3.2.

Avionics Systems Laboratory (Building 16)

Construction

The south wing (Wing S) of Building 16 was designed in the early 1960s by a combination of A/E firms headed by Brown & Root, Inc. of Houston; the east and north wings (Wing E and Wing N, respectively) were designed by The Lummus Company in January 1964.⁵³ Wing S was constructed first, by the joint venture team of C.H. Leavell and Company of El Paso, the Morrison-Knudsen Company, Inc. of Boise, Idaho, and Paul Hardeman, Inc. of Stanton, California, beginning in December 1962. It was followed by Wing N, which was completed in March 1964; Wing E was built in 1965. The first two areas totaled roughly \$1.94 million; the last area cost approximately \$1.89 million.⁵⁴ As originally constructed, the Wing N was a large high bay area, sectioned into various simulators; Wing S was almost entirely office space; and Wing E had a mixture of office and laboratory areas.

Over its lifetime, the ASL has undergone few physical changes. The largest was a 5,600 square foot addition to the north end of Wing N, constructed in 1993.⁵⁵ Internally, various mezzanine levels (ranging from roughly 1,200 to 3,000 square feet) were built within the high bay area; and various rooms have been joined, subdivided, or otherwise altered, as new requirements needed to be met.

Shuttle Avionics Integration Laboratory (SAIL)

The concept behind the SAIL was formed in the 1960s, with the introduction of an Acceptance Checkout Equipment (ACE) system for the Apollo Program, developed “for subsystem and integrated system testing of the Apollo spacecraft command and service modules [CSM].”⁵⁶ ACE stations were established not only at JSC (for testing the CSM in simulated space and lunar environments), but also at KSC (complete range of subsystem and integrated system tests of the spacecraft up to and including launch conditions), North American Aviation in Downey, California (initial systems testing at the CSM’s manufacturing plant), and Grumman Aircraft Engineering Corporation in Bethpage, New York (initial testing of the Lunar Excursion Module at its manufacturing plant). Through the ACE system, the spacecraft’s primary functional systems, such as navigation and control, communications, and environmental control, could be tested simultaneously.⁵⁷

⁵³ Brown & Root Inc., et al., Houston. “Building No. 16, Spacecraft Research Office & Lab.” August 31, 1962. On file, JSC EDCC [File No. NASA-101-4]; The Lummus Company, Houston. “Building No. 16, Spacecraft Research Office & Lab.” January 1964. On file, JSC EDCC [File No. NASA-101-18].

⁵⁴ NASA JSC. “Real Property Record-Building 16.” On file, JSC Real Property Office, Center Operations Directorate.

⁵⁵ Brown & Root Inc., et al.; The Lummus Company; NASA JSC, “Building 16.”

⁵⁶ “Apollo Preflight Acceptance Testing Station Operational.” *Space News Roundup*. (3, 23), September 2, 1964, 8.

⁵⁷ “Apollo Preflight Testing.”

With the introduction of the Space Shuttle Program, NASA wanted something similar to test the systems of the new spacecraft. In 1973, a small simulator, what later became known as “Early SAIL,” was constructed in the high bay of Wing N. The “Early SAIL” consisted of a cockpit area, which sat on top of a built-up platform, and a payload bay area, comprised of a raised “double-wide cable tray.”⁵⁸ All of the associated equipment, such as the hydraulics simulator, the communications and tracking subsystem panels, and the engineering laboratory equipment (i.e., computer stations and monitors), sat in the space below and around the cockpit and payload bay. This device helped NASA’s engineers with the development of the orbiter’s systems, and as their design evolved, so did the “Early SAIL.” Eventually, the job outgrew the simulator, and in January 1974, JSC’s Avionics Systems Engineering Division (ASED) officially established the present-day SAIL.⁵⁹

Under the direction of ASED, the SAIL was developed by Rockwell International (prime contractors for the construction of the orbiter) and Lockheed Martin (contracted by NASA to provide Engineering Services).⁶⁰ As originally fabricated, the facility consisted of the Shuttle Test Station (STS), a Shuttle Dynamics Simulator (SDS), a Test Operations Center (TOC), a Computer Test Set (CTS), and a Shuttle Avionics Test Set (SATS). The STS, a high-fidelity replica of a Space Shuttle orbiter given the tail number “OV-095,” was constructed in the same position as the “Early SAIL.”⁶¹ The SDS was installed at the northern end of the first floor of Wing S; the TOC was established directly to the south of the STS on the first floor of the high bay; the CTS was assembled on the mezzanine level of the high bay, to the east of the STS; and the SATS was placed along the south wall of the high bay mezzanine.⁶² The build-up of this infrastructure, as well as the installation of the avionics equipment, computer equipment, and wiring, took approximately four years to complete. The SAIL was officially accepted in its original configuration, patterned after the Orbiter *Enterprise*, on February 21, 1977, for its first assignment: providing support for the ALT program.⁶³

Beginning in 1977, prior to the completion of the ALT flights, preparations began for retrofitting the SAIL for its next assignment, supporting the Orbital Flight Test (OFT) program.⁶⁴ The first project to be started was the construction of the Guidance, Navigation, and Control (GN&C) Test Station (GTS), directly to the south of the STS. The GTS, which consisted of a single-seat cockpit with its avionics and other equipment surrounding it, was mainly built to assist the STS by focusing on testing the orbiter’s GN&C systems that did not require use of the high-fidelity applications.⁶⁵

⁵⁸ Frank Svrcek. “3-2-1-Mark: A History of the Shuttle Avionics Integration Laboratory (SAIL); 1969-2006.” Self published, January 2007, 29.

⁵⁹ “JSC Establishes Shuttle Avionic Integration Lab.” *Roundup*. (13, 3), January 4, 1974, 4.

⁶⁰ Svrcek, 25, 30.

⁶¹ United Space Alliance. “Shuttle Avionics Integration Laboratory.” Presentation, November 15, 2005, 7.

⁶² Svrcek, 30.

⁶³ NASA JSC. “Building 16.” See pages 3 and 4 for more information about the ALT program.

⁶⁴ See page 4.

⁶⁵ Svrcek, 35-36.

Following the completion of the ALT flights, work began on reconfiguring the STS for the OFT phase. Since its original model, the *Enterprise*, had only flown as a glider within the Earth's atmosphere, many of the flight systems necessary for a full Space Shuttle mission had not been incorporated into the orbiter or the simulator; therefore, the STS needed additional equipment or alterations to the original apparatus. The model for these changes was the first flight-ready vehicle, the Orbiter *Columbia*, which would fly the OFT missions. Within the flight deck, modifications included the installation of the orbiter's aft flight deck and new overhead control consoles. A large amount of additional wiring was also needed within the crew compartment, the payload bay, and the aft compartment for the Space Shuttle's propulsion elements. In conjunction with this new wiring, the Marshall Mated Elements System (MMES) lab was established in its own room to the east of the STS at the mezzanine level. The consoles and equipment were provided and installed by MSFC; the first test of the system was successfully accomplished early in July 1978.⁶⁶

In conjunction with the changes and additions to the test stations, the support areas of the SAIL underwent their own upgrades and alterations. The TOC was remodeled to provide a separate room (along the south wall of the high bay) for the Rockwell Test Conductor and the NASA Test Director, and its equipment was upgraded to provide the capability for handling the additional data flow. Other modifications included moving the SATS area so it would be adjacent to the STS cockpit, and the installation of the Launch Processing System (LPS) equipment to the southeast of the GTS. Additionally, the SDS was enhanced to accommodate the new MMES equipment, as well as a "more sophisticated atmospheric model and a simulation of the two Orbital Maneuvering System (OMS) engines."⁶⁷

With the introduction of the operational phase of the Space Shuttle Program, following the successful completion of the OFTs, the SAIL underwent additional modifications to reconfigure it for its new mission. Nearly every subsystem of the lab was affected during the three month renovation period, during which time the SAIL was non-operational. In general, over 10,000 wiring changes were made to the flight system, including wiring for the "Head Up Displays" in the commander and pilot stations; redundancies were added for the power system; and command authentication was added to the uplink system. Other improvements included updated Non-Avionics Test Station (NTS) models, new telemetry firmware, and upgraded flight software. Additionally, the TOC was moved to the LPS area on the mezzanine level of the high bay and received brand new computers and displays; the original TOC became a holding area for the peripherals and front-end processors that supported the new operations center.⁶⁸

Since the start of the operational phase of the SSP (mid-1982), the SAIL has undergone a few physical modifications, as well as various hardware and equipment/wiring changes, most of which were based on changes to the Space Shuttle vehicles. One of the first alterations to the SAIL was the removal of the GTS in 1983, due to the decrease in testing demands on the lab

⁶⁶ "MMES/SAIL First Test is Success." *Marshall Star*. (18, 42), July 5, 1978, 2; Svrcek, 35-36, 42-45.

⁶⁷ Svrcek, 35-36, 46-47.

⁶⁸ Svrcek, 49; Gregory C. Blackburn, interview by Jennifer Ross-Nazzal, May 9, 2009, Houston, TX, Manuscript on file, Tessada & Associates, Houston, TX, 7.

following the OFT program; other early changes involved the installation of some new lab computers.⁶⁹ In 1987, additional wiring and circuit breakers were added to the STS, as well as additional instrumentation as a result of changes made to the Space Shuttle fleet following the *Challenger* accident. Also at this time, the SAIL was interconnected with another test facility in the ASL, the JSC Avionics Engineering Laboratory (JAEL), in response to the upgrade of the shuttle's General Purpose Computers (GPCs). This link allowed the STS to retain the original GPCs with the ability of switching over to the new GPCs, which were installed in the JAEL, to run verification testing on either configuration until all of the orbiters were fitted with the new computers. In 1989, GTS II was installed in the SAIL to aid the STS in testing the new GPCs; it was dismantled in 1993.⁷⁰

Throughout the early 1990s, additional small changes were made to the facility based on the Extended Duration Orbiter pallet and NASA's decision to dock with the Russian Space Station *Mir*. These alterations included additional wiring for the systems, some new interface hardware, and new simulation models. In 1996, the Vehicle Automated Checkout system, developed by Rockwell to conduct checkouts of the orbiter during modification periods, was installed in the SAIL for testing, as was the Shuttle Multi-function Electronic Display Subsystem (MEDS) Mixed-fleet Station (SMMS). Using the old GTS II cockpit, the SMMS was fitted with the old orbiter cockpit display system, in preparation for the installation of the new MEDS system to the STS the following year.⁷¹ As with the GPC tests, this configuration would allow the SAIL to run tests using either the old cockpit configuration (with the SMMS) or the new cockpit configuration (with the STS), depending on which orbiter was flying. Further modifications were made in response to the ISS program (additional cabling for the Orbiter Docking System simulator, new math models, and new NTS hardware); and a new image generation system was installed in 1999.⁷²

A few additional changes to the SAIL occurred, beginning in the year 2000. Early in the year, the Modular Memory Unit was installed, which replaced the Mass Memory Unit, the Ops Recorder, and the Payload Recorder. Following the *Columbia* accident (2003), modifications were made to the lab for the Orbiter Boom Sensor System and the ET digital camera. Like most of the other changes, these involved new hardware interfaces, new simulation models, and new flight system wiring. Between 2005 and 2006, an entirely new TOC was constructed and equipped with more advanced technology and hardware. The old TOC continued to support work in the SAIL until the new center was finished; it has since been dismantled.⁷³ The most recent modification to the

⁶⁹ Svrcek, 51-52.

⁷⁰ Like the original GTS, the second one was limited by the fact that it only contained the equipment in the forward flight deck of the orbiter. It could, however, run three times as many tests per day as the STS due to new technological advances that were incorporated into the new simulator. Svrcek, 54-55, 58.

⁷¹ The SMMS was removed ca. 2007 and loaned to the Strategic Air and Space Museum in Ashland, Nebraska. Louis Parker, JSC Exhibits Manager. Email message to Abdul Hanif, JSC. April 7, 2009.

⁷² Svrcek, 58-64.

⁷³ Don Magnusson. Personal communication with Joan Deming and Patricia Slovinac of ACI, November 3, 2009, Houston, Texas.

laboratory has been the installation of the equipment necessary to support the Station-Shuttle Power Transfer System modification to the orbiters.⁷⁴

SAIL Functions

Throughout its history, the SAIL has served as a large, complex laboratory “where avionics and related hardware (or simulations of hardware), flight software, flight procedures, and associated ground support system equipment” have been “brought together for integration and mission verification testing” in order to certify shuttle hardware and software for flight. Additionally, the SAIL performs operational support, which includes real-time support of missions in progress, integration of payloads, and the investigation of anomalies.⁷⁵ The majority of testing has been conducted using the STS, although there were periods of time when a second, smaller simulator was installed in the lab to provide support to the STS.⁷⁶ These smaller simulators typically did not have the same range of capabilities as the STS, since they only replicated the flight deck of the crew compartment, while relying on computer systems to simulate the rest of the shuttle’s features. They proved to be extremely useful, however, when major changes, such as the updated GPCs or the MEDS cockpit, were being installed in the flight orbiters. During these periods of time, the STS was upgraded with the new hardware/software for initial testing and verification, while the smaller simulators retained the original configuration for mission support operations. Once a modification was verified, the orbiters were typically upgraded at different times; therefore, the SAIL retained these simulators until all orbiters had been changed.⁷⁷

Modifications to the SAIL have typically been based on a desired change for the orbiter, but have also resulted as a response to an unanticipated event (for example, the *Challenger* or *Columbia* accidents). Changes to the configuration of the SAIL have historically followed a typical flow pattern.⁷⁸ First, the hardware or software change is presented to the SAIL engineers, and a project lead is assigned who forms a project team. A project plan is then developed, which defines the objectives of the test program; the testing and checkout procedures; the specific the SAIL configuration to be used; and a time line for the testing process. This document is given to the SAIL management, who gives the okay for the project to be put on the facility schedule.⁷⁹

In the case of a hardware change, when the modification kit arrives, the SAIL technicians conduct an inventory to ensure all pieces are there, and then install the component into the simulator and conduct basic engineering checkouts to check voltage and circuitry. A software upgrade is delivered to the laboratory via fiber optic cables, from which it is loaded into the

⁷⁴ Svrcek, 66-75.

⁷⁵ NASA JSC. “Shuttle Avionics Integration Laboratory.” JSC-13037, Rev. B, July 1990.

⁷⁶ See pages 15-16.

⁷⁷ For example, *Atlantis* was the first orbiter to receive the MEDS cockpit upgrade in 1998; *Endeavour*, the last orbiter to be fitted with the new equipment, was upgraded in 2004.

⁷⁸ This same flow process is also generally used for mission-specific software, which is uploaded and tested in SAIL prior to the flight. Don Magnusson. Personal communication with Joan Deming and Patricia Slovinac, ACI. November 3, 2009.

⁷⁹ NASA JSC. “SAIL Configuration.” JSC-11845, Rev. C, June 1980, Section 4.

SAIL computer terminal. Once this is complete, specific dates and times are scheduled for the integration and verification testing procedures.

Integration tests are the first to be conducted and are used to identify and correct any implementation or procedural errors. The various tests under this category evaluate and verify that all subsystem interfaces are operating properly; all hardware and software are correctly working together; the redundancy systems are activating when necessary; and the integration between the STS and the MMES, LPS, etc., are properly functioning. If all is well, the acceptance testing, which includes verification of hardware and software mission capabilities and verification of flight operation procedures, begins. These tests are conducted through all necessary mission phases, and incorporate both normal situations and anomaly/contingency situations. The SAIL can simulate pre-launch operations, lift-off, ascent, orbital operations (including guidance, navigation, flight control, rendezvous, etc.), deorbit, entry, landing, and rollout. Anomaly/contingency situations are written into the test software. When all tests are completed, the data is collected, reviewed, and assembled into a final report.⁸⁰

In order to complete its mission, the SAIL is comprised of various elements (the STS, MMES, SDS, SATS, NTS, LPS and TOC) that work together to “allow a functional ‘flight’ of the avionics systems.”⁸¹ The STS, which contains the Orbiter Flight System (OFS), is the key component within the SAIL. It is a full-scale, high-fidelity replica of the orbiter, complete with flight software; forward, aft, and payload avionics bays; and all other avionic and nonavionic components, or simulations thereof within an orbiter. The STS contains a replica flight deck, middeck, payload bay, and aft compartment. Although the flight deck is fully equipped with all of the control panels found in the actual orbiter, the remainder of the STS “looks like a full-sized Orbiter stripped of its skin with its wires and connectors bared.”⁸²

Since the STS is a stationary object located within a building, there are restrictions to its capabilities. For example, it cannot be launched, or otherwise moved about, nor can an actual SSME, SRB, or ET be attached to the simulator and ignited. Therefore, the SAIL contains both the MMES and the SDS to simulate such activities. The MMES includes all of the equipment to provide simulations of the SSMEs, SRBs, and ET; the SDS provides a simulation of the vehicle’s movement while on-orbit or during entry and landing operations.

The SATS provides the equipment for loading, controlling, and dumping the shuttle’s computers. It is programmed to start and stop all laboratory elements and flight computers at the same time, and is set to record specific data during the various tests. To help provide a high-fidelity simulation, the NTS is capable of generating non-avionic, environmental conditions, such as temperatures and pressures. In addition, this system can simulate other factors, such as the opening of a hatch or the operation of a valve or sensor. The LPS allows the SAIL to test and verify all ground checkout and launch functions, and aids in the verification of launch software;

⁸⁰ United Space Alliance. “Shuttle Avionics Integration Laboratory.” Informational pamphlet, October 2005; NASA JSC, “SAIL Configuration,” Section 4.

⁸¹ “JSC Establishes Shuttle Avionic Integration Lab;”

⁸² “Lab in Building 16 tests, re-tests Orbiter avionics.” *Roundup*. (19, 6), March 21, 1980, 1.

the equipment is a subset of KSC hardware and software used to launch a space shuttle. The TOC provides a working area for the test team. From this space, the engineers and technicians can control the operations, insert an anomaly into the test process, and record data from the individual test sequences.

Aside from these internal elements, the SAIL also has interfaces with supporting laboratories external to the ASL, including the Inertial Systems Laboratory (ISL), the Electronic Systems Test Laboratory (ESTL), the Software Production Facility (SPF), the Orbiter Data Record Complex (ODRC), and the Mission Control Center (MCC).⁸³ The external laboratories are linked to the SAIL for a variety of reasons. The connection to the ISL allows the SAIL to incorporate Inertial Measurement Units, Rate Gyro Assemblies, or other vehicle sensors into the testing process. The connection to the ESTL provides confirmation that any of the new hardware or software is compatible with the radio frequency links between the orbiter and the ground stations, relay satellites, detached payloads, and/or EVA communications systems. The link between the MCC and the SAIL is a communications link that allows transmittal of orbiter telemetry/engine data between the two facilities, as well as the transfer software to the SAIL from the SPF, and data from the SAIL to the ODRC. This link is especially important for real-time mission support.

Systems Engineering Simulator (SES) Facility

The SES is a set of three simulators, the SES-Shuttle Forward Cockpit (SFC); the SES-Shuttle Aft Cockpit (SAC); and the High-Fidelity Engineering Simulator (HFES), used by the Software, Robotics, and Simulation Division. The SFC and the SAC date to the early 1970s, and were used in support of the ALT program (Photo No. 145); the HFES was constructed ca. 1998 to support the Space Station, but was never used for that purpose, and subsequently modified for the SSP. These simulators were designed to be used by Shuttle engineers and software developers for developmental studies and on-orbit troubleshooting. In more recent years, astronauts have used the SAC and the HFES to train for on-orbit operations, such as the use of the Remote Manipulator System (RMS) arm and docking to the ISS; the SFC has been used for ascent and entry training, for which it is capable of generating visual cues to match any runway the orbiter could land on, including the Shuttle Landing Facility at KSC; the runway at Edwards Air Force Base; the White Sands Space Harbor; or any of the Transatlantic Abort Location sites.⁸⁴

Electrical Power Systems Laboratory (EPSL)

The EPSL is comprised of two main areas: the Space Shuttle Electrical Power Distribution and Control (EPDC) Breadboard and the High Voltage Test Area (HVTA). The Space Shuttle EPDC Breadboard is a high fidelity model of the electrical subsystems used in the Space Shuttle fleet. It is used to verify design compatibility with any proposed changes to the basic Shuttle electrical system and to verify that any payload that uses electrical power from the Shuttle is compatible

⁸³ Through the Mission Control Center, the SAIL can also connect to the Payload Operations Control Center at MSFC. United Space Alliance, 12.

⁸⁴ Clinton Clements. Personal communication with Joan Deming and Patricia Slovinac of ACI. November 6, 2009.

with the Shuttle electrical power subsystems. In conjunction with the Breadboard, the HVTA is used to evaluate electrical components and subsystems that operate between 28 volts to 300 volts. These tests are performed in a standard laboratory environment or in a vacuum jar capable of providing an environment that matches the conditions found in Low Earth Orbit. Additionally, both areas of the EPSL can be used for real-time testing, destructive testing, and anomaly testing of the various electrical components found on the Space Shuttle.⁸⁵

⁸⁵ Larry Detrick. Personal communication with Joan Deming and Patricia Slovinac of ACI. November 3, 2009.

Physical Description

The Avionics Systems Laboratory (ASL) has approximate overall dimensions of 386' in length (north-south), 356' in width (east-west), and 40' in height. The entirety sits on a reinforced concrete slab foundation and has a flat, built-up roof. The facility is divisible into three sections: an east wing (Wing E), a south wing (Wing S), and a north wing (Wing N).

Wing E measures approximately 159' in length (north-south), 146' in width (east-west), and stands 30' in height, and has walls constructed of plate glass. The first floor walls are shaded by a 9'-deep pre-cast exposed aggregate facing (PEAF) panel canopy that is supported by free-standing pillars, which sit roughly 4' from the glass wall and are spaced at 28'-0" on center. The upper floor is shaded by a 4'-deep PEAF panel canopy. A pair of glass swing doors, in the center of the east elevation, serves as the main entrance to this wing. The north and south elevations each have a metal swing door near Wing N, which the west side abuts. Both floor levels contain offices around the perimeter with support areas in the center.

Wing N, which contains the SAIL facility, stands roughly 40' in height, and has walls composed of a steel skeleton and faced with PEAF panels. The wing measures approximately 260' in length (north-south) and 115' in width (east-west), and features two rolling doors on the north elevation, with two metal swing doors, which are accessed via a concrete landing with steps at both ends, in between. The west elevation also has one rolling door near the south end. Towards its north end is a small, one-story projection with a set of double doors on its west side. The remaining two elevations of Wing N are void of openings. Internally, this wing is comprised of a large high bay area, with various second floor mezzanines throughout its area.

Wing S, located directly south of Wing N, is two stories in height and measures approximately 290' in length (east-west) and 151' in width (north-south). Its walls are of similar construction to Wing E, and it has a height of 30' as well. Two pairs of glass swing doors are located on the west elevation, and one pair of glass swing doors is situated on the south elevation. Two pairs of metal swing doors are on the north elevation, one to either side of Wing N. Internally, most of the first floor and the entire second floor contains offices and support areas for the facility. The first floor also contains a few lab areas.

As originally defined by the "Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program, Lyndon B. Johnson Space Center, Houston, Texas," the significance of the ASL is derived from "the Shuttle Electrical Power System Test Facility (Rm. 147) and its control room (Rm. 147A) within the south wing, as well as Rooms 1004A, 1008, 1010, 1012, 1016, 1040, and 2005 in the north wing, which make up the Shuttle Avionics Integration Laboratory."⁸⁶ However, it should be noted that during the field work for this documentation package, the individual areas that are part of the SAIL, and/or

⁸⁶ ACI, 6.2.4. It should also be noted that at the time of the original survey, a Shuttle Mixed-MEDS Simulator was located at the southern end of Wing N, but has since been removed (see page 16).

contribute to the significance of the facility were further clarified by Don Magnusson, as detailed below.⁸⁷

SAIL

The SAIL is composed of various areas throughout the entire ASL. The principal components of that laboratory, which directly contribute to the significance of the ASL, are Rooms 1010, 1012, and 1016 (the Shuttle Test Station) and Room 2004 (the Marshall Mated Elements System) in Wing N, and Rooms 2101 and 2109 (the Test Operations Center) in Wing E. The remaining areas are considered support facilities, and include Room 1008 (the TSS Test Conductor area); Room 2002A (the Launch Processing System and Shuttle Avionics Test Set area); the shop areas in Rooms 1014 and 1018; the library area above Room 1012, the Global Positioning Area in Room 2002B, and the old Test Operations Center in Rooms 2010 and 2010A, all in Wing N; and Rooms 100 and 100A (the Vehicle Dynamics Simulator), in Wing S.

The Shuttle Test Station (STS), a full-scale mockup of the orbiter minus the wings and landing gear, is located along the west wall of Wing N, and is oriented so that the forward end is at the south. The simulator is comprised of three distinct areas: Room 1010 (forward end/crew compartment), Room 1012 (midfuselage/payload bay), and Room 1016 (aft compartment). Room 1010 has approximate overall dimensions of 28' in length (north-south) and 19' in width (east-west), and is comprised of two levels that correspond to the orbiter's flight deck and middeck. The middeck level sits roughly 2'-6" above the high bay floor, and has roughly the same spatial layout as that on the orbiter. Unlike the orbiter, or other simulators used for astronaut training, this middeck has no finished walls or stowage compartments. Rather, its walls are comprised of banks of cable racks that contain all of the wiring to form the electronic equivalent of the real orbiter. The forward bulkhead is composed of two sets of eight shelves, each of which has a curved outer edge to mimic the shape of the orbiter (Photo No. 28), which correspond to the orbiter's Avionics Bay 1 (east) and Avionics Bay 2 (west). The rear bulkhead has a central opening that looks into the midfuselage area with cable racks on either side; that to the west replicating the orbiter's Avionics Bay 3 (Photo Nos. 30, 31). The east and west walls of the middeck area are gypsum board with a few electrical and utility connections; a wood swing door in the west wall provides the main access to the middeck.

A small ladder at the northeast corner of the middeck leads to the flight deck, which can also be reached externally by the surrounding access platforms. Unlike the rest of the STS, the flight deck area has the same external shape as that of a real orbiter; and unlike the middeck, it contains the faceplates, switches, knobs, etc., found in an actual flight deck. Since it is not a training facility, the flight deck does not contain flight-like commander's and pilot's seats (Photo Nos. 18, 19), nor does it have the floor connections for mission specialist seats. Additionally, there are many exposed wires throughout the compartment that are not exposed on the orbiter, including a cable rack underneath the aft control station (Photo No. 22). Additionally, many of the rear starboard and port consoles, which form the mission specialist work stations, are not present in

⁸⁷ Magnusson.

this simulator. Also incorporated into the flight deck are the six forward windows, two overhead windows, and two aft windows found on the orbiter (Photo No. 25).

The midfuselage/payload bay area (Room 1012) of the STS has approximate overall dimensions of 53' in length (north-south) and 28' in width (east-west). The area is framed by Room 1010 at its south end, Room 1016 at its north end, and a line of six I-beam columns, roughly 8' high, on both the east and west sides. On each side, the columns support a triangular-shaped cable tray that runs the entire length of the space (Photo Nos. 34-37). A beam extends east to west across the area at each of the six columns to support a cable tray, to connect the cables on the two sides. On the floor of the high bay area, below the cable trays, are clusters of two or three electronic/data panels, which extend for the whole length of the area; space is left between the clusters to allow personnel access to the equipment (Photo No. 49). Also in this area are various computer stations and box nodes (Photo No. 47), and other specific instrumentation panels (Photo No. 48).

Room 1016, an enclosed area that contains the equipment found in the aft end of the orbiter, has rough dimensions of 18' in length (east-west) and 10' in width (north-south). It is accessed by a wood swing door on either the east or west walls. Mounted to the inside of the walls are various cable racks, some of which run vertical, others are similar to those in the middeck area (Photo Nos. 51-52, 58-60). Internally, the room is divided into two levels, the upper of which is reached via a ladder in the northwest corner. On both levels, there are free-standing boxes of wires that replicate the orbiter's Avionics Bays 4, 5 (upper level; Photo No. 61) and 6 (lower level; Photo No. 55) small control consoles for various pieces of equipment (Photo No. 62), electro-mechanical actuators to simulate some of the orbiter's systems (Photo No. 56), and other electronic equipment to simulate different moving components of the orbiter, such as the body flap and elevons (Photo No. 57). Additional support consoles for the aft compartment are situated outside of the room, on both the first and second floor levels (Photo Nos. 63-64).

Room 2004, which contains the MMES, sits on a second level area of the Wing N high bay. This space is an enclosed room that has approximate dimensions of 48' in length (north-south) and 31' in width (east-west), and has a floor to ceiling height of roughly 7'. The walls are comprised of gypsum board, and there is an acoustical tile ceiling and a raised tile floor. Access to the room is provided by a metal swing door on the west wall, a pair of metal swing doors on the north wall, or a pair of metal swing doors on the south wall. Internally, there are various banks of electrical and data panels, some of which line one of the walls (Photo Nos. 65, 66, and 68). Others are perpendicular to a wall, or situated within the center of the room. Also within the MMES area are various control consoles (Photo No. 67) and computers (Photo No. 69).

The TOC sits at the southwest corner of Wing E and is comprised of two spaces, a control room (Room 2109; Photo No. 71) to the east and a conference room (Room 2101; Photo No. 76) to the west. Both of the areas have gypsum board walls, an acoustical tile ceiling, and carpeted floors; their adjoining wall is fitted with glass panels to provide visual access between the two rooms. There is also a metal swing door at the south end of this wall to provide personnel access between the two spaces. The control room has rough overall dimensions of 48' in length (north-

south) and 37' in width (east-west), and a ceiling height of roughly 9'. Throughout the room are various hubs of computer consoles for the different engineering/technical specialties involved with the SAIL systems (Photo Nos. 72-75). Two sets of consoles sit parallel to the west wall, one next to the windows and the other near the north wall. Additionally, three banks of consoles extend in the east-west direction, one near the south wall; the other two to its north. The conference room measures approximately 32' in length (north-south), 17' in width (east-west), and also has a ceiling height of 9'. The room is accessed through a metal swing door on its south wall. Within the area is a large conference table, oriented along a north-south axis; a pull-down screen sits along the north wall.

The remaining support areas of the SAIL vary in size and function, and are located throughout the ASL. The TSS Test Conductor area sits along the west wall of Wing N, to the south of the FSS. It is an open space with an acoustical tile ceiling and a raised tile floor that contains various consoles, electrical/data panels, and computers (Photo Nos. 77-79). On the second level of the Wing N high bay, positioned around the FSS, is 'Room 2002A', which contains the LPS, the SATS, and the data library; a small enclosed area within this space is the Global Positioning Area (GPS; Room 2002B). The LPS is equipped with two parallel arced banks of consoles (Photo Nos. 80-82) within the center, and rows of data collection panels along the walls (Photo No. 83). The SATS is a small area, whose limits are defined by banks of data panels, computers, and electrical consoles (Photo Nos. 84, 85). The data library area sits directly above the midfuselage section of the FSS and contains racks for holding film cartridges and video tapes, which contain data from many of the tests that have been conducted in the SAIL facility. The old TOC also sits on the second level, within the southeast corner near the junction of Wing E and Wing N. The two shop areas sit on the main floor of the Wing N high bay, one to the east of the FSS and the other to its west. The Vehicle Dynamics Simulator is located within the north end of Wing S (Photo Nos. 87-89). Room 100 is considered the control area and contains various computer stations and consoles; Room 100A contains the data collection equipment.

SES

The specific areas of the SES facility that contribute to the significance of the ASL are Rooms 1024, 2005, and 1040, all located within Wing N. Room 1024 sits near the northeast corner of the Wing N high bay, and has approximate overall dimensions of 50' in length (north-south) and 43' in width (east-west); it has a partial ceiling height of roughly 11'. Within the west half of this room is the SES-SAC. The shell of the SES-SAC (Photo Nos. 90 and 91) is constructed of plywood, and has a box-shaped east half and an aft flight deck-shaped west half. This massing corresponds to the internal arrangement of the simulator, which is divisible into two parts. Within the west half of the compartment is a partial replica of the aft flight deck on an orbiter (Photo Nos. 92-94). It contains, in their proper position, the two aft windows that look into the payload bay, as well as the two overhead windows. Each is fitted with a video system that generates simulated images of what an astronaut would see through that particular window at specific times (Photo No. 95). Along the west wall of the simulator is a replica aft control station, which only has the control switches, knobs, or hand controllers used during on-orbit operations, such as RMS positioning. The east half of the simulator is an open area, which essentially serves

as a preparation/viewing area for engineers, technicians, or even astronauts. It is to this area that the two simulator entrances, a wood swing door on each the north and south side, open. To the north, where the two internal halves meet, is a small computer station, used to control the simulations (Photo No. 97).

Directly above Room 1024, sits Room 2005, which contains the SES-SFC. This room has rough overall dimensions of 43' in length (east-west), 36' in width (north-south), and 19' in height, and is typically accessed from Room 1024 by a set of steps at its northeast. The SES-SFC is situated in the southeast corner of the room, and like the SES-SAC, is constructed of plywood. The entire simulator is shaped like the flight deck of a real orbiter, except for the entrance on the west side, which takes the form of a rectangular projection (Photo Nos. 98-100). The entrance, a wood swing door, leads to an open area in the back (south) of the simulator that corresponds to the location of the orbiter's aft flight deck. Like the open area in the SES-SAC, this space serves as a preparation/viewing area; the control station sits in the southeast corner (Photo No. 105). The north half of the simulator contains a full-scale replica of a "glass cockpit" along the north wall; in the northeast and northwest corners are simulated side control panels, which only partially include the control switches and knobs found in the real flight deck (Photo Nos. 101-103). The simulator also contains the six forward and two overhead windows; however, only the four central forward ones are equipped with a video system that projects images of views seen through those windows during launch and landing sequences (Photo No. 104). This visual system is keyed into the simulators' controls, so as the hand controllers are moved, the views in the windows change accordingly. In addition, the simulator has an audio system to mimic the sounds associated with launch and landing operations.

Room 1040 constitutes the eastern two-thirds of the ca. 1992 north addition to Wing N. The room itself has rough overall dimensions of 79' in length (east-west), 59' in width (north-south), and 30' in height. Within the western half of the room is the HFES, which is an enclosed simulator comprised of a trapezoidal section to the northeast and a spherical half-dome to the southwest (Photo Nos. 106-108). The trapezoidal area measures approximately 32' in overall length (northeast-southwest), 15' in width (northwest-southeast), and 24' in height; the spherical half-dome has a diameter of roughly 19'. The internal surface of the dome is comprised of a projection screen (Photo Nos. 114, 115) that surrounds a replica aft control station, situated in the spherical center. The aft control station rests on a raised platform (Photo Nos. 109, 110), and like the SES-SAC, only contains the control switches, knobs, and hand controllers used for on-orbit maneuvers (Photo Nos. 111-113). To its west is a computer control station, used to run the simulations. Along the internal perimeter of the dome is an access path for technicians, so they can reach various data and electrical ports on the sides of the control station's platform (Photo No. 117). The platform is reached by a set of stairs that rises from a similar access path along the internal perimeter of the trapezoidal area. This area is also used as a preparation/viewing area by engineers, technicians, and astronauts. The support framework for these walls also holds six sets of projectors arranged in two tiers of three that are used to provide the visual images on the dome's screen (Photo No. 116).

EPSL

The Shuttle EPSL is located towards the west end of Wing S in Rooms 147 and 147A. This area has overall dimensions of approximately 57' in length (north-south), 29' in width (east-west), and 11' in height; Room 147A, which was built in the northeast corner of Room 147 has rough dimensions of 20' in length (east-west) and 11' in width (north-south). The EPSL has walls faced with gypsum board, an acoustical tile ceiling, and raised tile floors, which provide space for the various cables to be run. Room 147 has two metal swing doors on its east wall, one each at the north and south end, and a pair of metal swing doors on the north wall, to the west of Room 147A. Room 147A can only be accessed through Room 147, by a metal swing door on its south wall; windows line the remainder of its south wall, as well as its west wall, providing a visual link between the two rooms.

Room 147 (Photo Nos. 118-120) is spatially configured into three specific areas: the EPDC Breadboard area; the HVTA; and the ISS area. The EPDC Breadboard area sits in the southwest corner of Room 147. It is arranged so that the load panels (Photo No. 123) sit along the south wall of the room and electrical power distribution assembly simulators extend along the west wall of the room, as well as form the north boundary of the Breadboard area (Photo Nos. 124, 125). The control console acts as the east boundary of the area and is centered between the north and south panel banks (Photo No. 121, 122). The HVTA sits directly to the north of the EPDC Breadboard area; its south row of electrical panels sits back-to-back with the north boundary of the Breadboard area. The HVTA contains two additional banks of consoles, one along the west wall and the other parallel to it towards the east (Photo No. 126). The ISS area sits at the northeast corner of Room 147, directly south of the control room. The control room (Room 147A) is equipped with two computer consoles, one each on the north and south walls at the west end (Photo No. 127); the remainder of the room contains metal storage cabinets.

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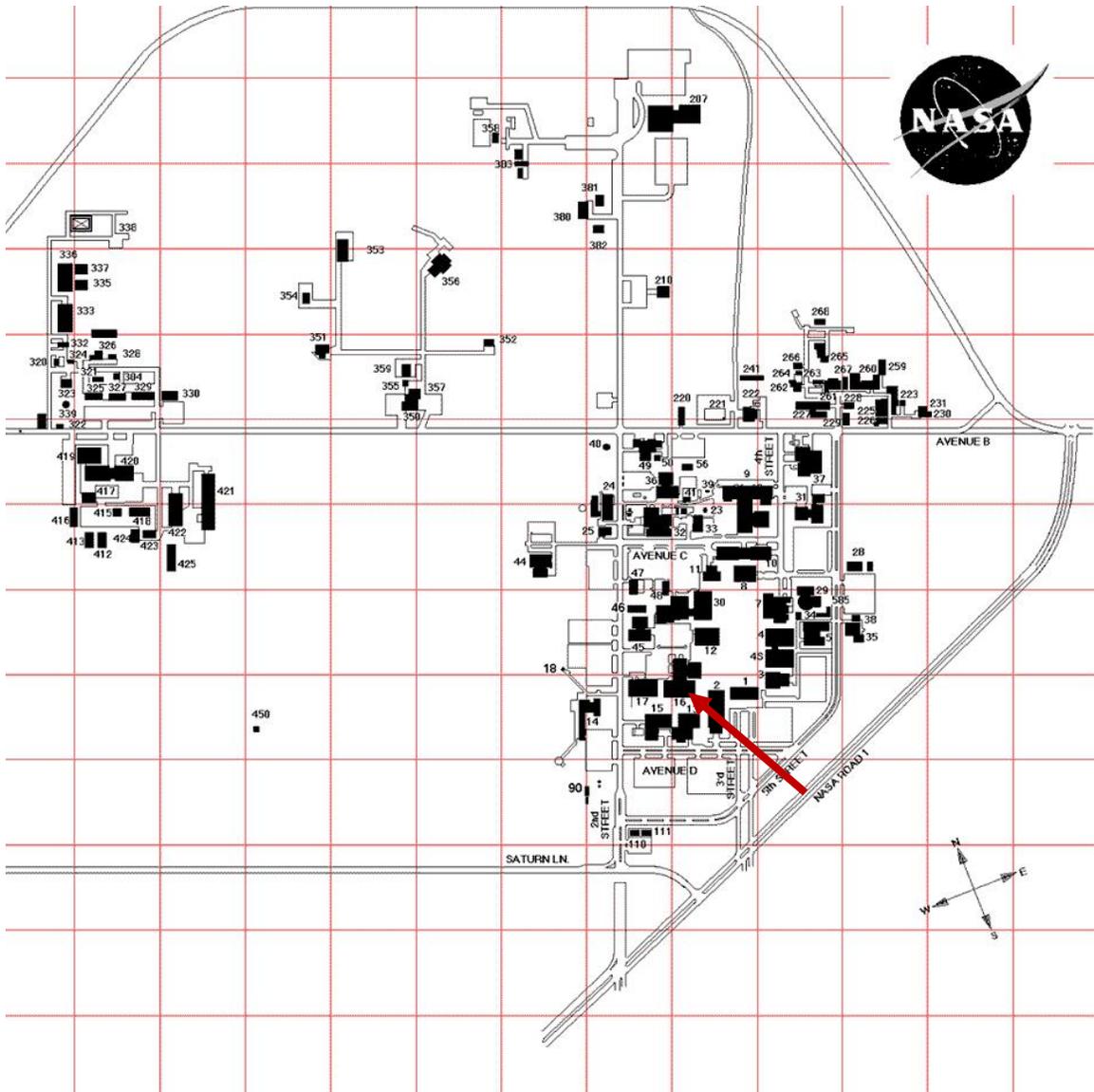


Figure 1. Location of the Avionics Systems Laboratory.
Source: JSC, 2006.

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Photographs ASL-1 through ASL-128 were taken by Patricia Slovinac, ACI; September 2009. Historic photographs (ASL-129 through ASL-148) are courtesy of the NASA JSC Imaging Center (Building 424), Houston, Texas; the negative number is given in parentheses.

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- ASL-49 Detail view of a 'Flexible Interface Expansion' panel in the support area, Room 1012 of the SAIL Flight Systems Simulator, camera facing northeast.
- ASL-50 View of the 'exterior' of the midfuselage/payload bay area, Room 1012 of the SAIL Flight Systems Simulator, camera facing southwest.
- ASL-51 View of the lower level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing southwest.
- ASL-52 View of the lower level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing southeast.
- ASL-53 Detail view of the wiring on the starboard side of the aft bulkhead, aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing west.
- ASL-54 Detail view of the wiring on the port side of the aft bulkhead, aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing east.
- ASL-55 Detail view of 'Avionics Bay 6' on the lower level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing southeast.
- ASL-56 Detail view of OMS electro-mechanical actuators on the lower level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing south.
- ASL-57 Detail view of elevon/body flap simulator on the lower level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing north.
- ASL-58 View of the upper level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing southeast.

- ASL-59 View of the upper level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing southwest.
- ASL-60 View of the upper level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing northeast.
- ASL-61 Detail view of 'Avionics Bay 4' on the upper level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing south.
- ASL-62 Detail view of 'SSME Controller' on the upper level of the aft compartment area, Room 1016 of the SAIL Flight Systems Simulator, camera facing northwest.
- ASL-63 Detail view of RCS/OMS simulator, just outside of Room 1016 of the SAIL Flight Systems Simulator, camera facing northwest.
- ASL-64 Detail view of SSME Interface for the SAIL Flight Systems Simulator, located in Room 2002A, camera facing northeast.
- ASL-65 View of the Marshall Mated Elements System area, Room 2004 of the SAIL, camera facing northeast.
- ASL-66 View of the Marshall Mated Elements System area, Room 2004 of the SAIL, camera facing northwest.
- ASL-67 Detail view of a console in the Marshall Mated Elements System area, Room 2004 of the SAIL, camera facing south.
- ASL-68 Detail view of a SRB actuator simulator in the Marshall Mated Elements System area, Room 2004 of the SAIL, camera facing northwest.
- ASL-69 Detail view of a host computer (Encore 2040 Seahawk) in the Marshall Mated Elements System area, Room 2004 of the SAIL, camera facing east.
- ASL-70 Detail view of a SRB avionics panel for the Marshall Mated Elements System area, just outside of Room 2004 of the SAIL, camera facing southeast.
- ASL-71 View of the Test Operations Center, Room 2109 of the SAIL, camera facing northeast.
- ASL-72 Detail view of the Non-Avionics Simulation Systems Engineer and Communications Systems Engineer consoles in the Test Operations Center, Room 2109 of the SAIL, camera facing northwest.

- ASL-73 Detail view of the Flight Control GN&C System Engineer and Guidance and Navigation Engineer consoles in the Test Operations Center, Room 2109 of the SAIL, camera facing northeast.
- ASL-74 Detail view of the ‘Sponsor’s’ console in the Test Operations Center, Room 2109 of the SAIL, camera facing northwest.
- ASL-75 Detail view of the USA Test Conductor’s console in the Test Operations Center, Room 2109 of the SAIL, camera facing northeast.
- ASL-76 View of the conference room (Room 2101) for the Test Operations Center of the SAIL, camera facing northeast.
- ASL-77 View of the Telemetry Simulation/System [TSS] Test Conductor Area, Room 1008 of the SAIL, camera facing southeast.
- ASL-78 Detail view of the video recording consoles in the TSS Test Conductor Area, Room 1008 of the SAIL, camera facing south.
- ASL-79 Detail view of the fiber optics consoles in the TSS Test Conductor Area, Room 1008 of the SAIL, camera facing east.
- ASL-80 View of the Launch Processing System/Checkout Control and Monitor Subsystem area, Room 2002A of the SAIL, camera facing southwest.
- ASL-81 View of the Launch Processing System/Checkout Control and Monitor Subsystem area, Room 2002A of the SAIL, camera facing northwest.
- ASL-82 Detail view of a row of consoles in the Launch Processing System/Checkout Control and Monitor Subsystem area, Room 2002A of the SAIL, camera facing southwest.
- ASL-83 Detail view of data collection panels in the Launch Processing System/Checkout Control and Monitor Subsystem area, Room 2002A of the SAIL, camera facing northwest.
- ASL-84 View of the Shuttle Avionics Test Set area, Room 2002A of the SAIL, camera facing northwest.
- ASL-85 Detail view of data panels in the Shuttle Avionics Test Set area, Room 2002A of the SAIL, camera facing southwest.
- ASL-86 View of the Data Library area, Room 2002A of the SAIL, camera facing northwest.

- ASL-87 View of the Vehicle Dynamics Simulator control area, Room 100 of the SAIL, camera facing north.
- ASL-88 View of the Vehicle Dynamics Simulator control area, Room 100 of the SAIL, camera facing southwest.
- ASL-89 View of the Vehicle Dynamics Simulator data console area, Room 100A of the SAIL, camera facing southeast.
- ASL-90 Exterior view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, camera facing northwest.
- ASL-91 Exterior view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, camera facing northeast.
- ASL-92 Interior view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, showing aft control station, camera facing northwest.
- ASL-93 Interior view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, showing starboard side, camera facing south.
- ASL-94 Interior view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, showing port side, camera facing north.
- ASL-95 Detail view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, showing simulated visual images in starboard window, camera facing west.
- ASL-96 Interior view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, showing overhead windows, camera facing west.
- ASL-97 Interior view of the Systems Engineering Simulator/Shuttle Aft Cockpit in Room 1024, showing back area with computer station, camera facing north.
- ASL-98 Exterior view of the Systems Engineering Simulator/Shuttle Forward Cockpit in Room 2005, camera facing northeast.
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- ASL-100 Exterior view of the Systems Engineering Simulator/Shuttle Forward Cockpit in Room 2005, camera facing south.

- ASL-101 Interior view of the Systems Engineering Simulator/Shuttle Forward Cockpit in Room 2005, showing “glass cockpit” and forward center console, camera facing north.
- ASL-102 Interior view of the Systems Engineering Simulator/Shuttle Forward Cockpit in Room 2005, showing forward overhead console, camera facing north.
- ASL-103 Interior view of the Systems Engineering Simulator/Shuttle Forward Cockpit in Room 2005, showing commander’s seat, camera facing northwest.
- ASL-104 Detail view of the Systems Engineering Simulator/Shuttle Forward Cockpit in Room 2005, showing simulated visual images in pilot’s windows, camera facing northeast.
- ASL-105 Interior view of the Systems Engineering Simulator/Shuttle Forward Cockpit in Room 2005, showing back area with computer station, camera facing east.
- ASL-106 Exterior view of the High-Fidelity Engineering Simulator in Room 1040, camera facing west.
- ASL-107 Exterior view of the High-Fidelity Engineering Simulator in Room 1040 (dome is visible to the left), camera facing north.
- ASL-108 Exterior view of the High-Fidelity Engineering Simulator dome in Room 1040, camera facing east.
- ASL-109 Interior view of the High-Fidelity Engineering Simulator in Room 1040, showing aft control console and stairs to the console, camera facing west.
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- ASL-111 Detail view of the aft control console in the High-Fidelity Engineering Simulator in Room 1040, camera facing west.
- ASL-112 Detail view of the aft starboard console in the High-Fidelity Engineering Simulator in Room 1040, camera facing southwest.
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- ASL-114 Detail view of the projection screen in the High-Fidelity Engineering Simulator in Room 1040 with overhead lights on, camera facing west.

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- ASL-116 Detail view of one of the projector banks in the High-Fidelity Engineering Simulator in Room 1040, camera facing northeast.
- ASL-117 Detail view of an electrical bank mounted to the aft control station platform in the High-Fidelity Engineering Simulator in Room 1040, camera facing northwest.
- ASL-118 View of the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing southwest.
- ASL-119 View of the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing northwest.
- ASL-120 View of the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing south.
- ASL-121 View of the “Breadboard Area” in the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing southwest.
- ASL-122 Detail view of the control console in the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing west.
- ASL-123 Detail view of a set of resistive load panels in the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing southwest.
- ASL-124 Detail view of a set of electrical power distributor assemblies simulators in the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing west.
- ASL-125 Detail view of a set of electrical power distributor assemblies simulators in the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing northwest.
- ASL-126 Detail view of a set of load assemblies simulators in the Shuttle Electrical Power Systems Laboratory, Room 147, camera facing southwest.
- ASL-127 External view of the computer room within Shuttle Electrical Power Systems Laboratory, Room 147A, camera facing northeast.
- ASL-128 Internal view of the computer room within Shuttle Electrical Power Systems Laboratory, Room 147A, camera facing west.
- ASL-129 Construction of the ASL, facing northeast (S63-19070).

- ASL-130 Construction of the Wing N high bay area in the ASL, facing east (S64-17632).
- ASL-131 Construction of the ASL, facing southeast (S64-26037).
- ASL-132 Construction of steel framework for the SAIL Flight Systems Simulator, facing southwest (S74-33795).
- ASL-133 Construction of the crew compartment for the SAIL Flight Systems Simulator, facing northwest (S77-30436).
- ASL-134 Construction of the crew compartment for the SAIL Flight Systems Simulator, facing south (S77-30447).
- ASL-135 Construction of the crew compartment for the SAIL Flight Systems Simulator, facing northwest (S78-29666).
- ASL-136 Construction of the crew compartment (middeck area) for the SAIL Flight Systems Simulator, facing southeast (S78-30235).
- ASL-137 Construction of the midfuselage/payload bay area for the SAIL Flight Systems Simulator, facing northwest (S77-30443).
- ASL-138 Construction of the midfuselage/payload bay area for the SAIL Flight Systems Simulator, facing southeast (S78-25920).
- ASL-139 Construction of the midfuselage/payload bay area for the SAIL Flight Systems Simulator, facing south (S78-29664).
- ASL-140 Construction of the aft compartment for the SAIL Flight Systems Simulator, facing southeast (S79-36343).
- ASL-141 Construction of the aft compartment for the SAIL Flight Systems Simulator, facing west (S79-36345).
- ASL-142 SAIL Flight Systems Simulator, facing southwest (S88-32489).
- ASL-143 Equipment installation in the Marshall Mated Elements System area for SAIL, direction unknown (S78-28287).
- ASL-144 Equipment installation in the Marshall Mated Elements System area for SAIL, direction unknown (S78-28288).
- ASL-145 View of the Systems Engineering Simulator, direction unknown (S75-30388).

- ASL-146 View of the Systems Engineering Simulator-Shuttle Forward Cockpit under assembly, direction unknown (S75-30396).
- ASL-147 View of the Systems Engineering Simulator-Shuttle Forward Cockpit under assembly, direction unknown (S78-29661).
- ASL-148 View of site preparations for the north addition to Wing N, facing southeast (S92-41396).

Photograph Nos. ASL-149 through ASL-167 are photocopies of engineering drawings. Original drawings are located at the Engineering Drawing Control Center, JSC, Texas.

- ASL-149 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-3, Brown & Root, et al., 1962
1ST FLOOR PLAN-SOUTH
Sheet 3 of 74
- ASL-150 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-5, Brown & Root, et al., 1962
2ND FLOOR PLAN-SOUTH
Sheet 5 of 74
- ASL-151 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-8, Brown & Root, et al., 1962
ELEVATIONS
Sheet 8 of 74
- ASL-152 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-10, Brown & Root, et al., 1962
ELEV'S., SECT'S. & DETL'S.
Sheet 10 of 74

- ASL-153 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-14, Brown & Root, et al., 1962
SECT., HIGH BAY AREA & DETAILS
Sheet 14 of 74
- ASL-154 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB;
SPACECRAFT CONTROL TECHNOLOGY LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-4, The Lummus Company, 1964
FIRST FLOOR PLAN-EAST
Sheet 4 of 74
- ASL-155 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB;
SPACECRAFT CONTROL TECHNOLOGY LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-6, The Lummus Company, 1964
SECOND FLOOR PLAN-EAST
Sheet 6 of 74
- ASL-156 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB;
SPACECRAFT CONTROL TECHNOLOGY LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-7, The Lummus Company, 1964
FIRST FLOOR PLAN-WEST
Sheet 7 of 74
- ASL-157 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB;
SPACECRAFT CONTROL TECHNOLOGY LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-9, The Lummus Company, 1964
SECOND FLOOR PLAN-WEST
Sheet 9 of 74

- ASL-158 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB;
SPACECRAFT CONTROL TECHNOLOGY LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-13, The Lummus Company, 1964
EXTERIOR ELEVATIONS
Sheet 13 of 74
- ASL-159 Photocopy of drawing
BUILDING NO. 16, SPACECRAFT RESEARCH OFFICE & LAB;
SPACECRAFT CONTROL TECHNOLOGY LAB
NASA, Manned Spacecraft Center, Texas
Drawing A-16-15, The Lummus Company, 1964
ELEVATIONS & SECTIONS
Sheet 15 of 74
- ASL-160 Photocopy of drawing
BUILDING 16
NASA, Lyndon B. Johnson Space Center, Texas
Drawing A-16-4, NASA JSC, 2009
FIRST FLOOR PLAN (SOUTH)
- ASL-161 Photocopy of drawing
BUILDING 16
NASA, Lyndon B. Johnson Space Center, Texas
Drawing A-16-7, NASA JSC, 2009
SECOND FLOOR PLAN (SOUTH)
- ASL-162 Photocopy of drawing
BUILDING 16
NASA, Lyndon B. Johnson Space Center, Texas
Drawing A-16-5, NASA JSC, 2009
FIRST FLOOR PLAN (NORTH)
- ASL-163 Photocopy of drawing
BUILDING 16
NASA, Lyndon B. Johnson Space Center, Texas
Drawing A-16-8, NASA JSC, 2009
SECOND FLOOR PLAN (NORTH)

- ASL-164 Photocopy of drawing
BUILDING 16
NASA, Lyndon B. Johnson Space Center, Texas
Drawing A-16-6, NASA JSC, 2007
FIRST FLOOR PLAN (EAST)
- ASL-165 Photocopy of drawing
BUILDING 16
NASA, Lyndon B. Johnson Space Center, Texas
Drawing A-16-9, NASA JSC, 2005
SECOND FLOOR PLAN (EAST)
- ASL-166 Photocopy of drawing
BUILDING NO. 16, AVIONICS SYSTEMS LABORATORY
NASA, Manned Spacecraft Center, Texas
Drawing A-16-18, The Lummus Company, 1993
EXTERIOR ELEVATIONS
- ASL-167 Photocopy of drawing
BUILDING 16
NASA, Lyndon B. Johnson Space Center, Texas
Drawing A-16-20, NASA JSC, 2008
ELEVATIONS & SECTIONS



ASL-1



ASL-2



ASL-3



ASL-4



ASL-5



ASL-6



ASL-7



ASL -8



ASL -9



ASL -10



ASL -11



ASL -12



ASL -13



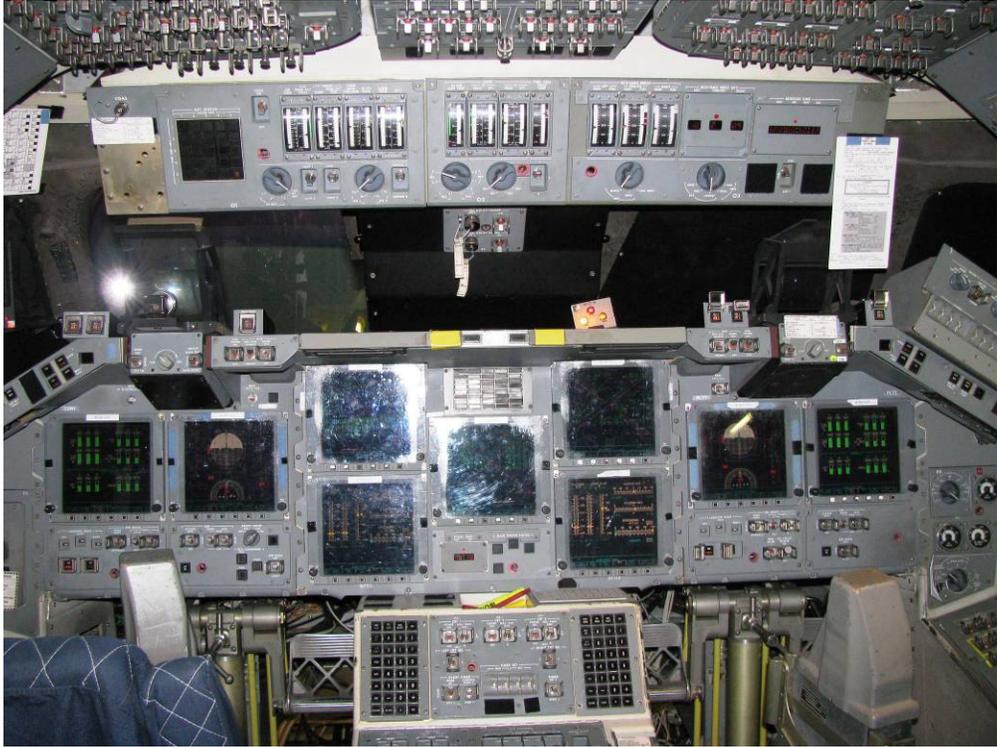
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ASL -17



ASL -18



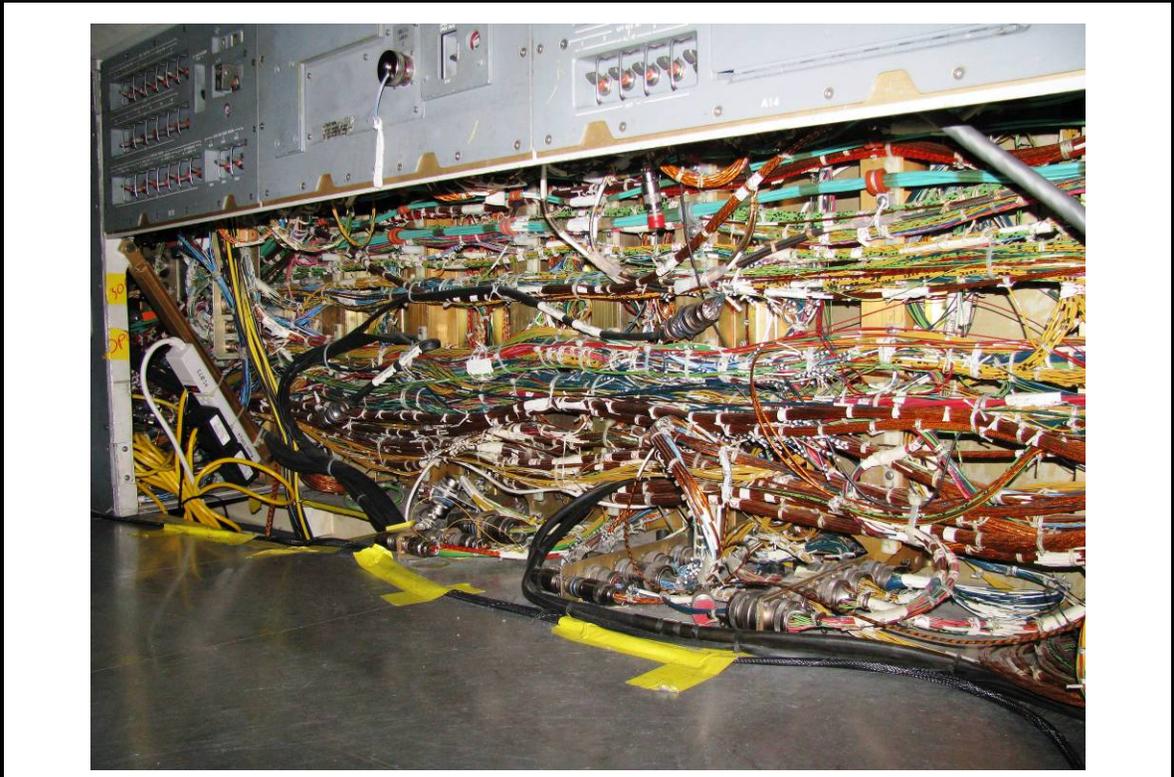
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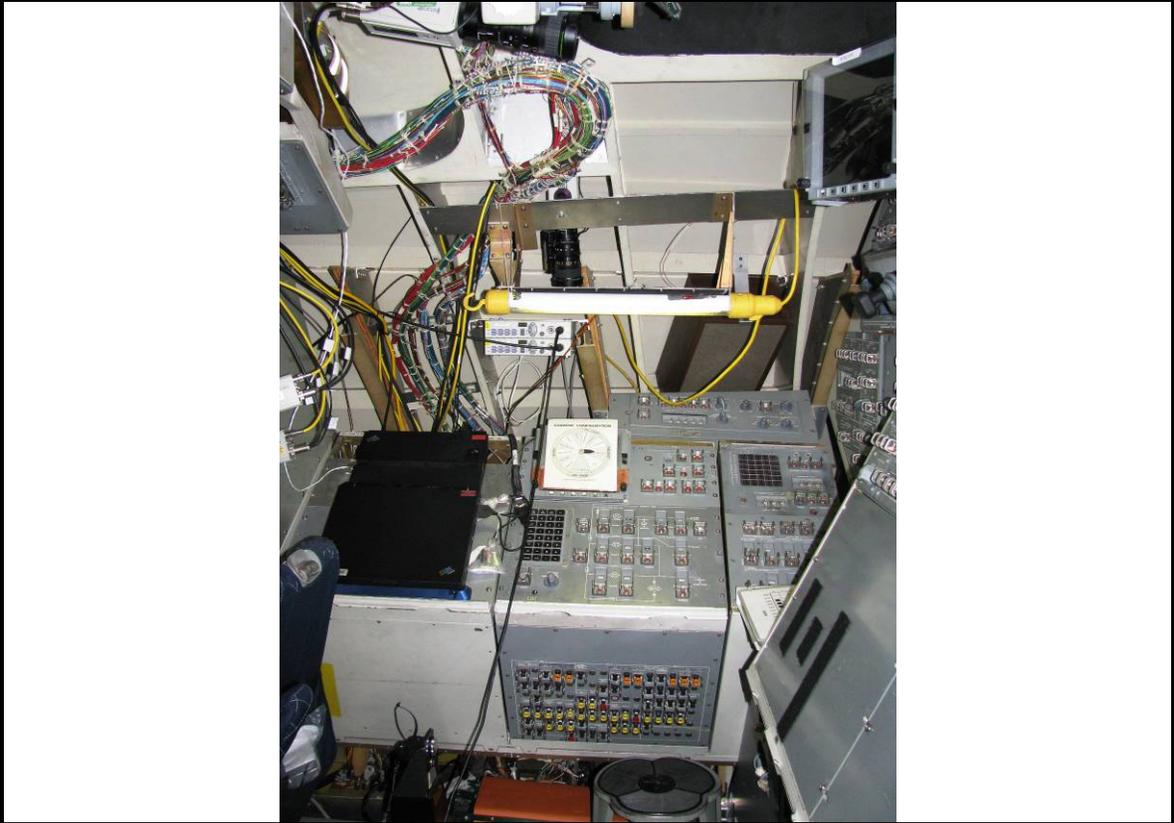
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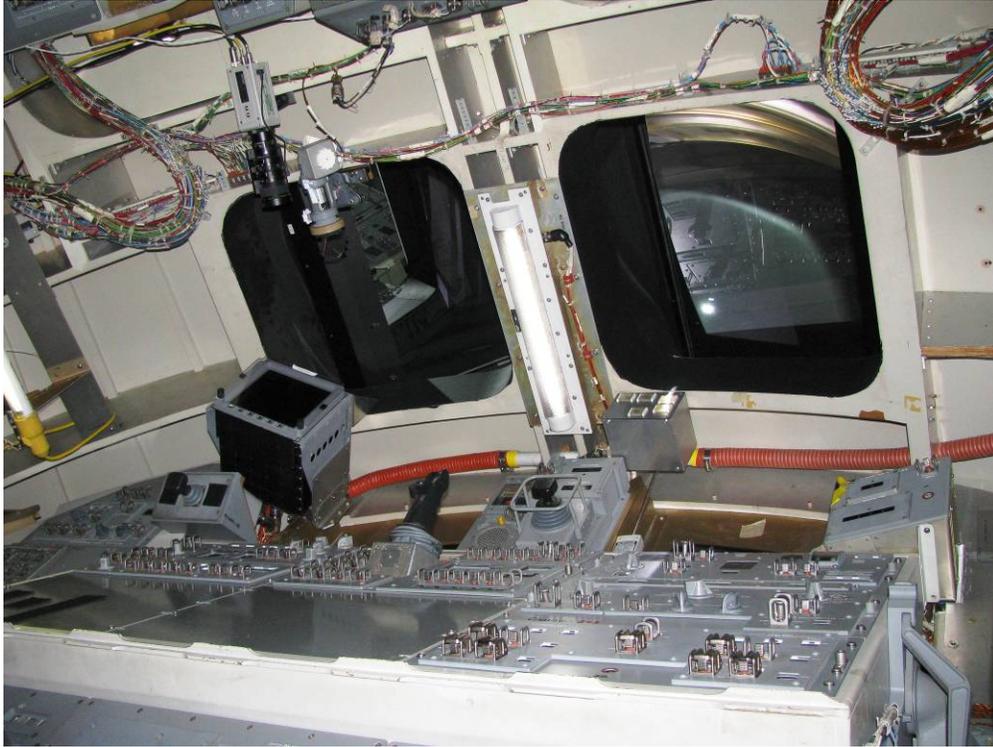
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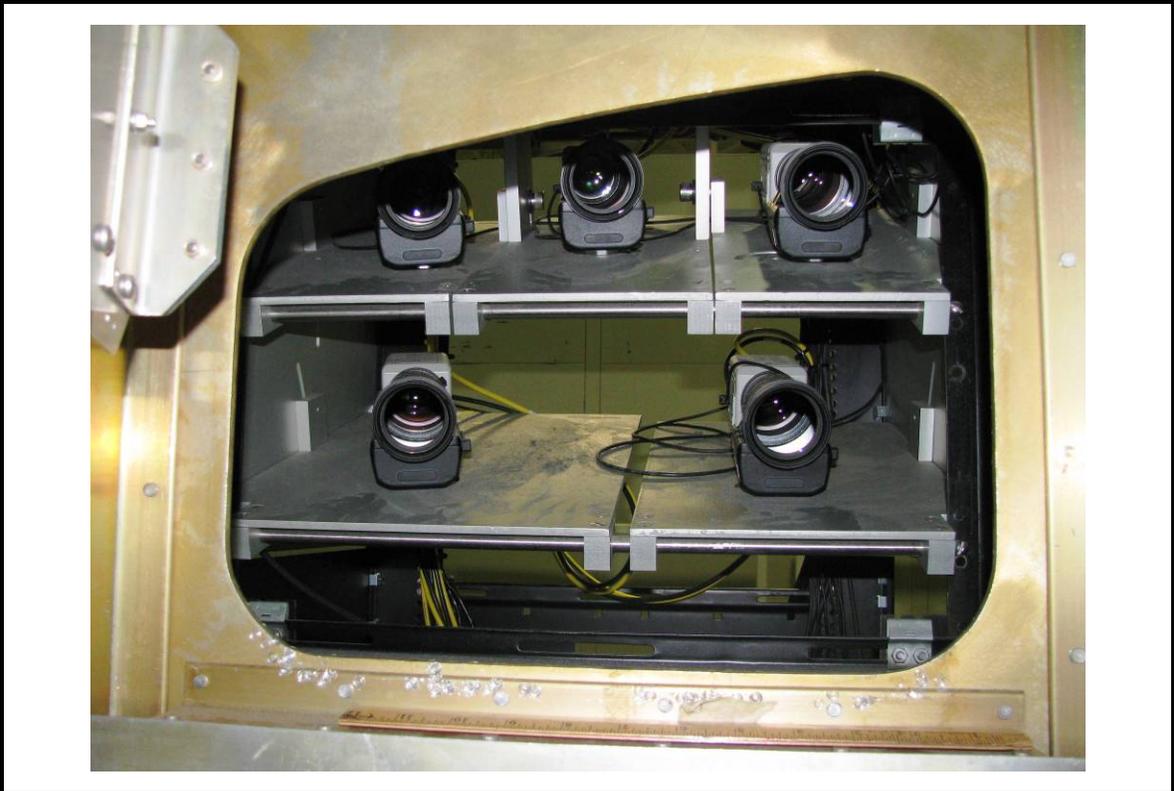
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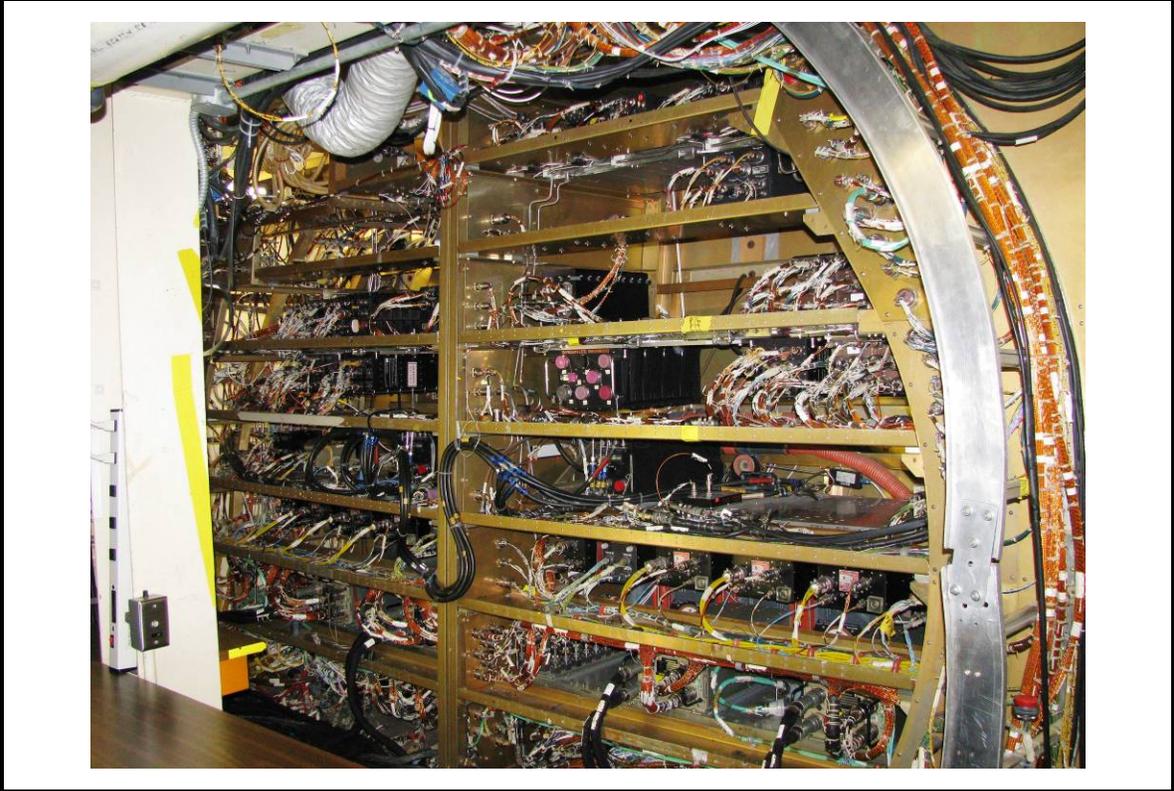
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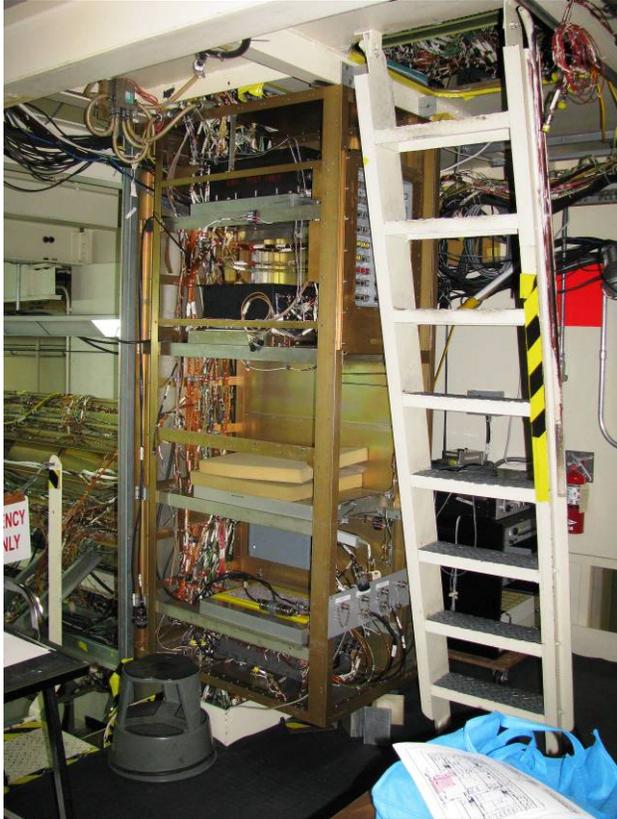
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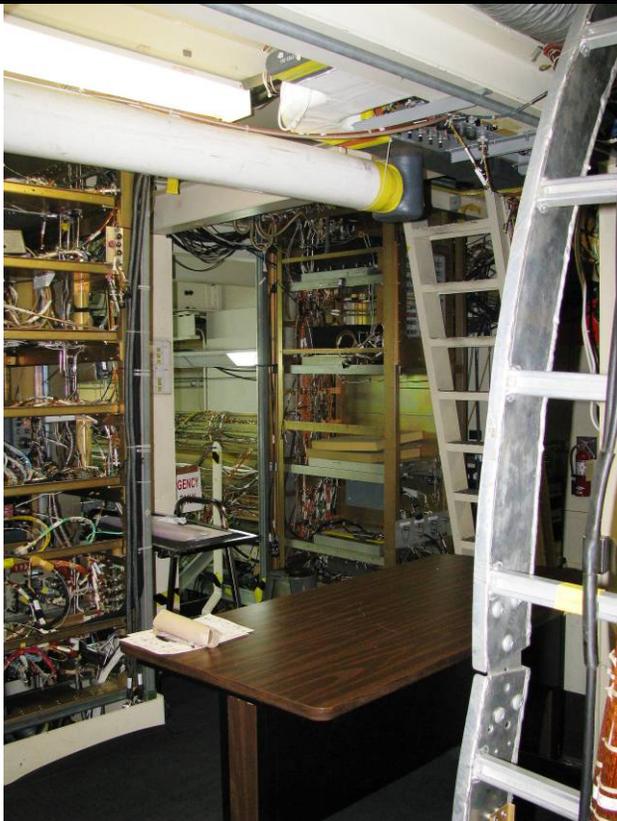
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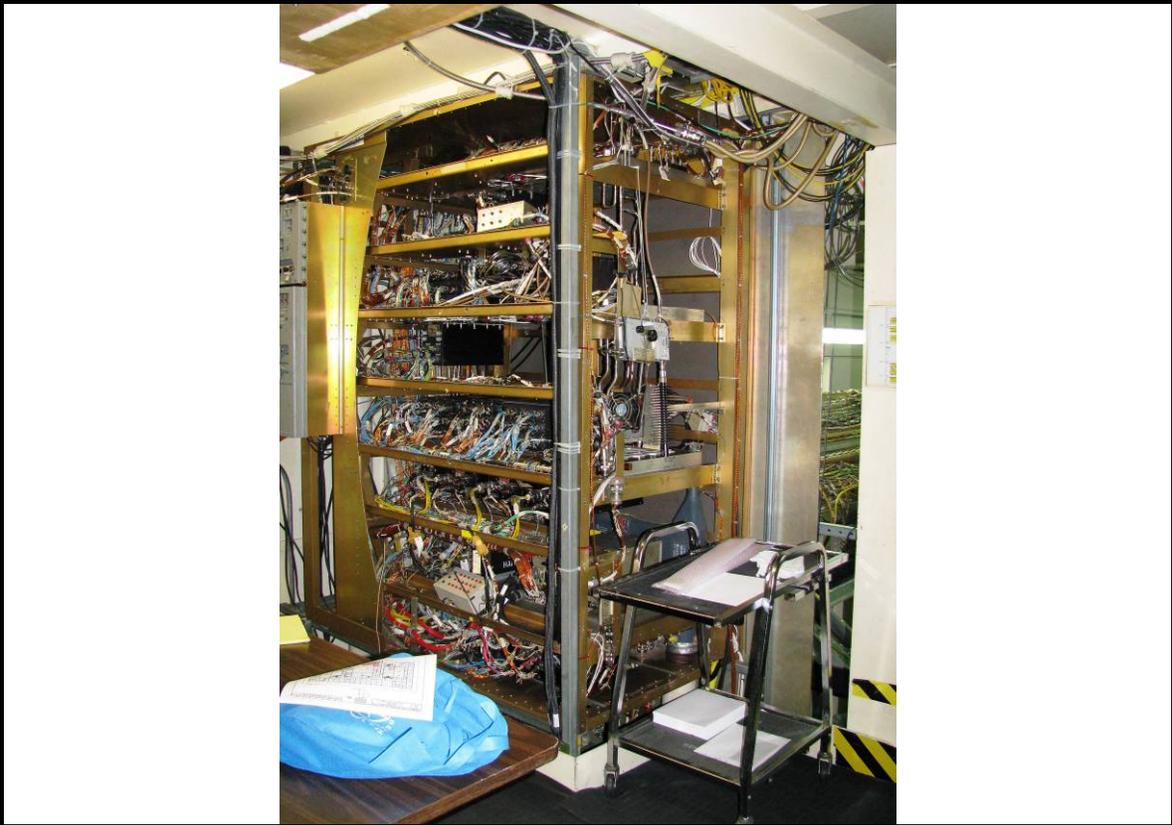
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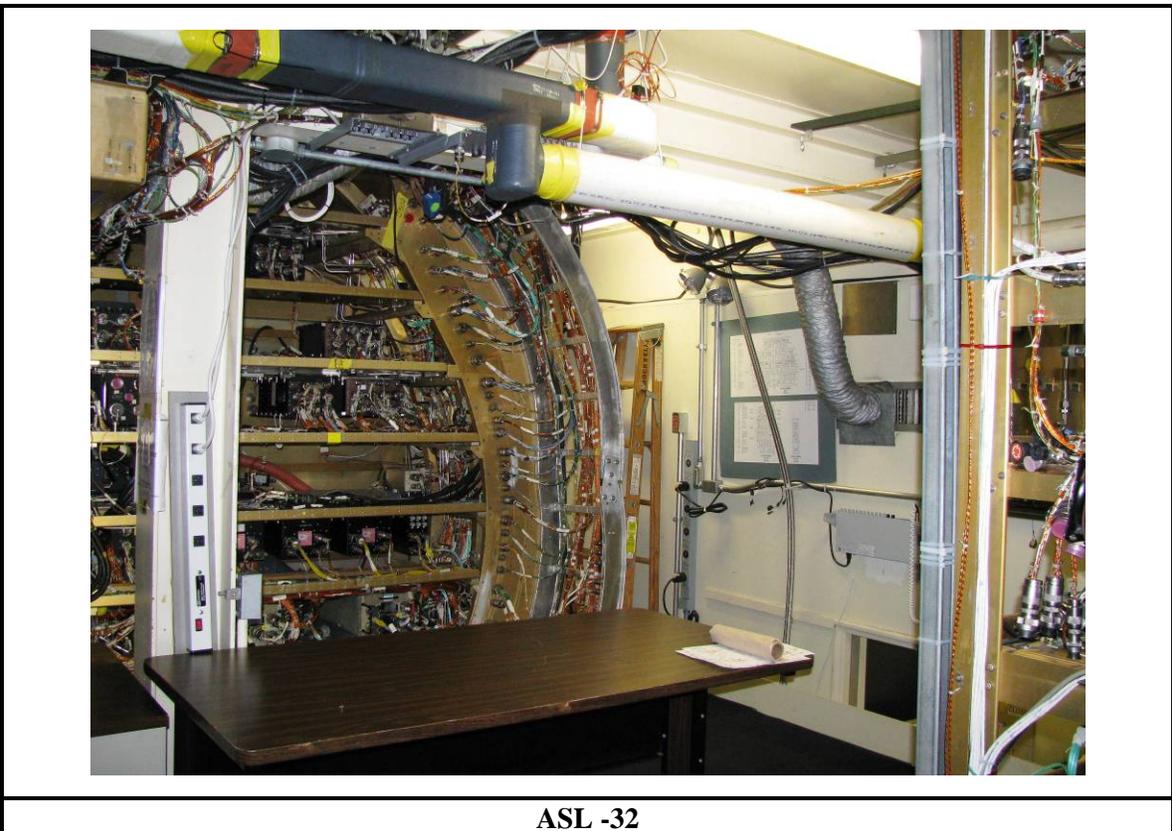
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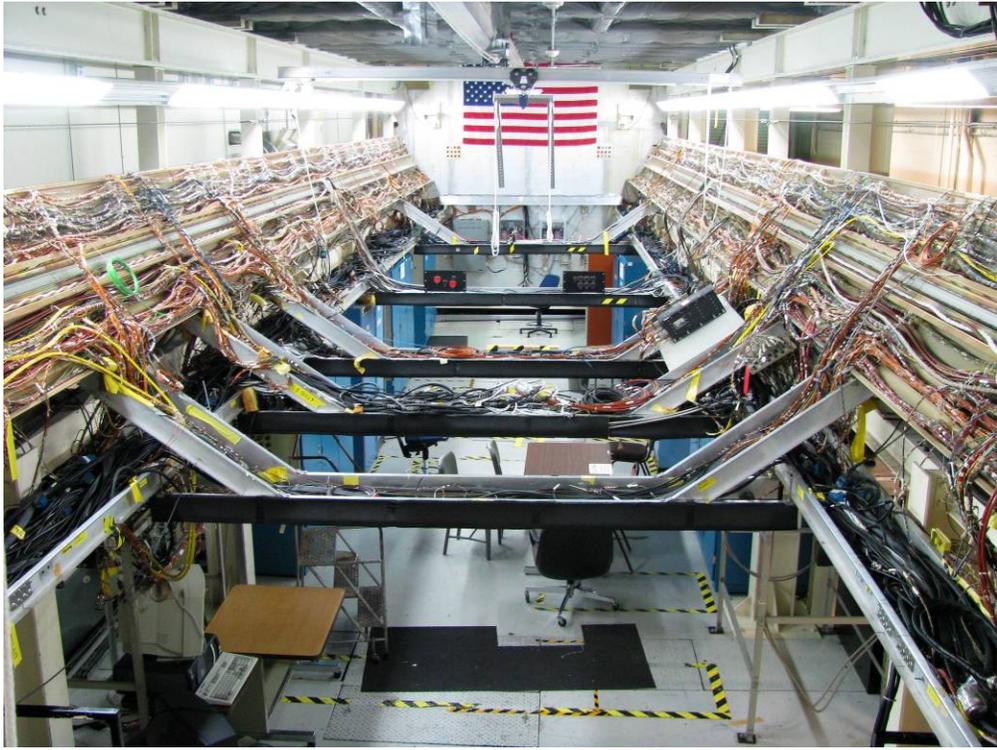
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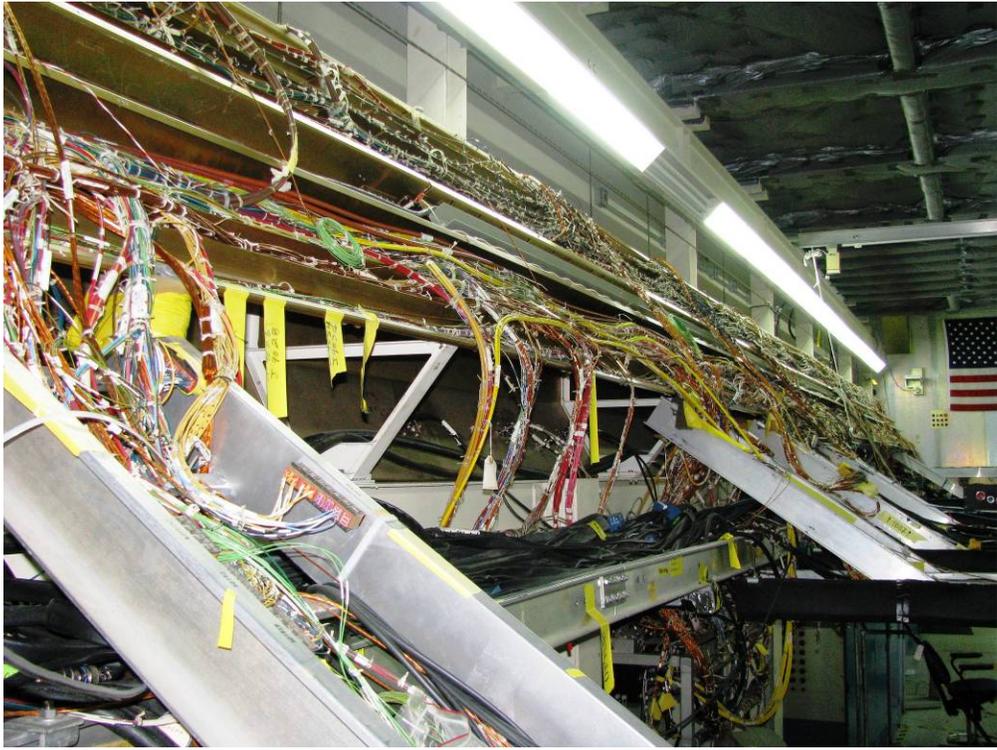
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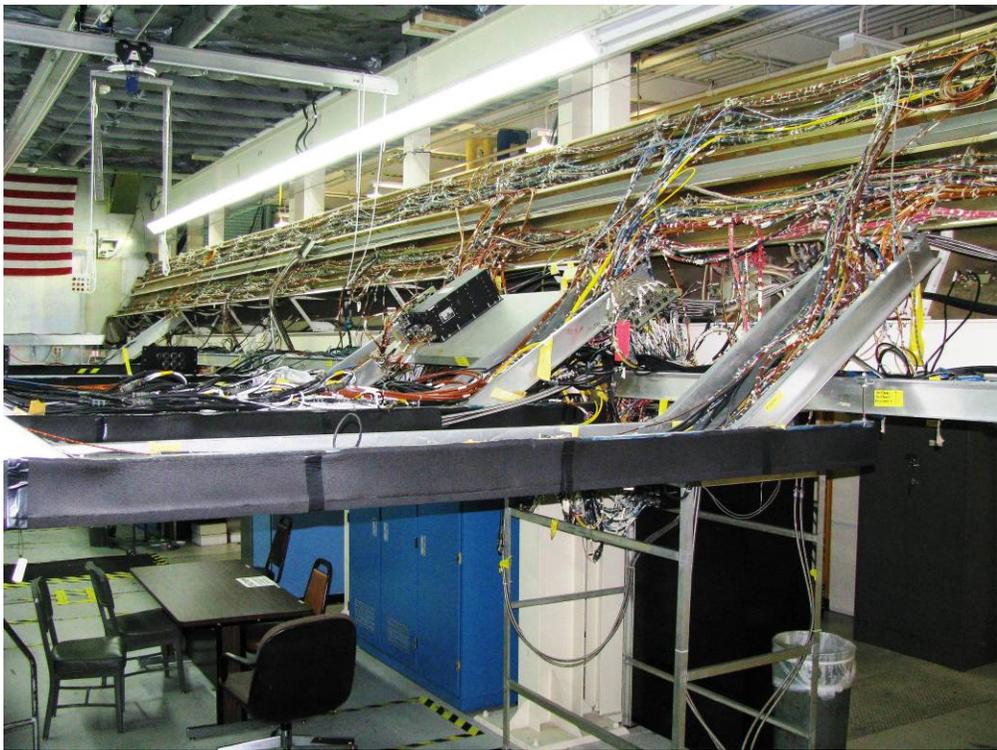
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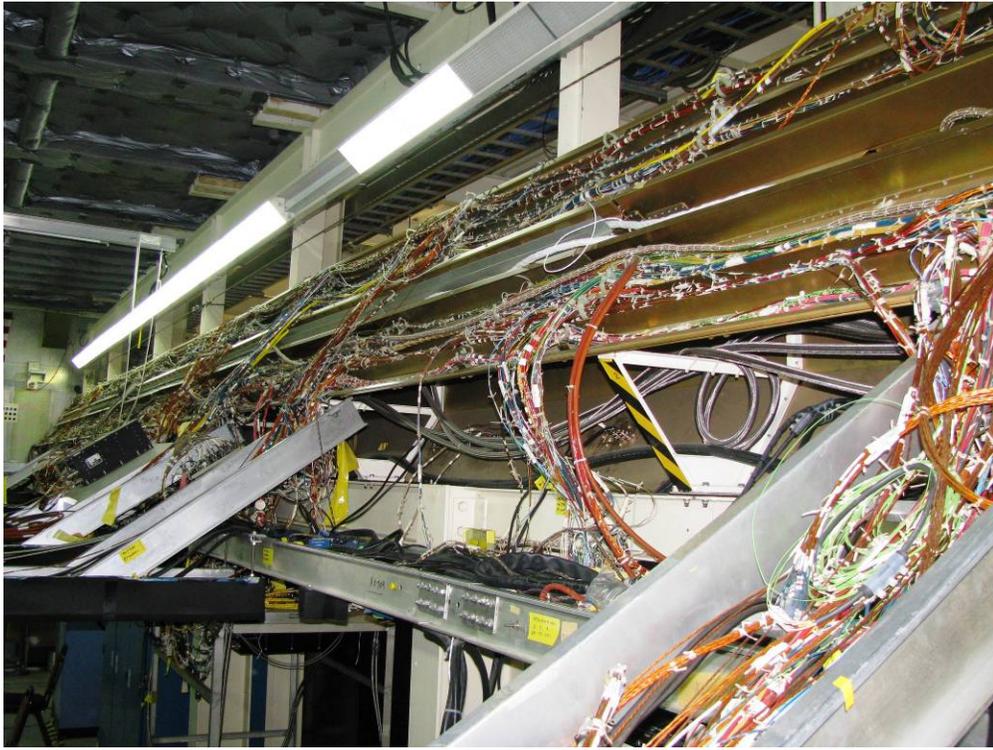
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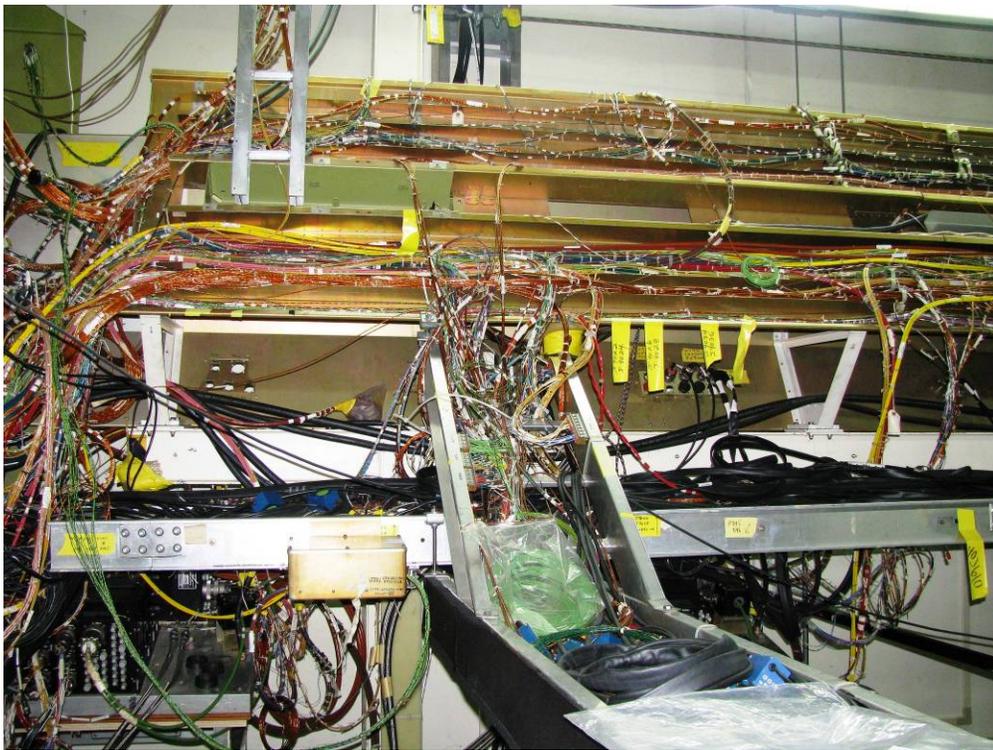
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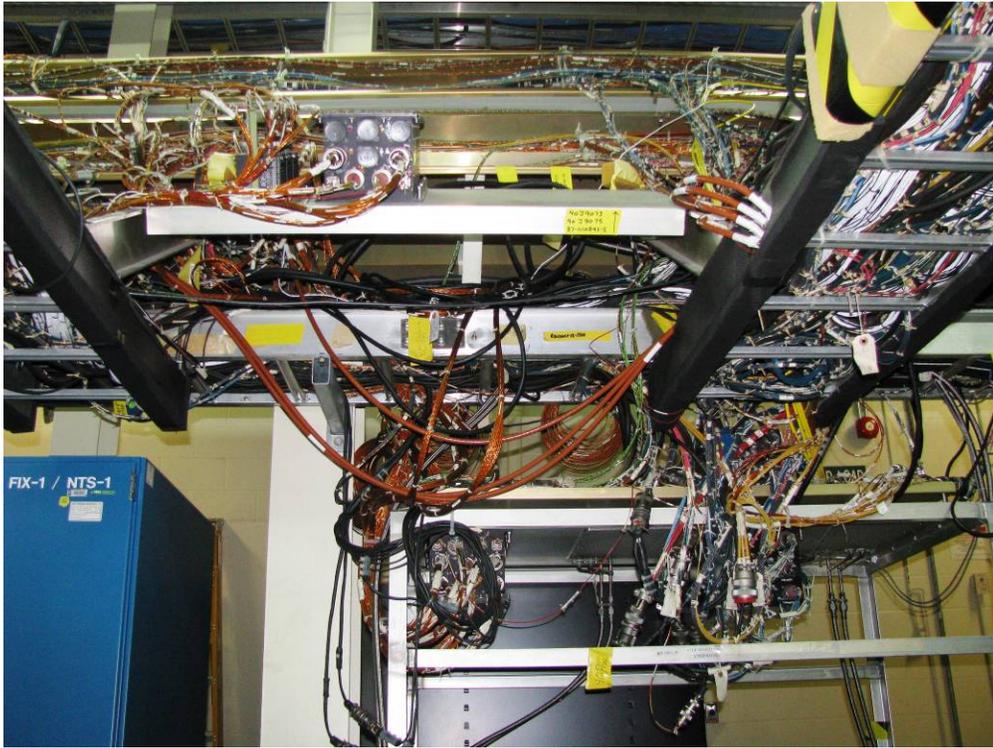
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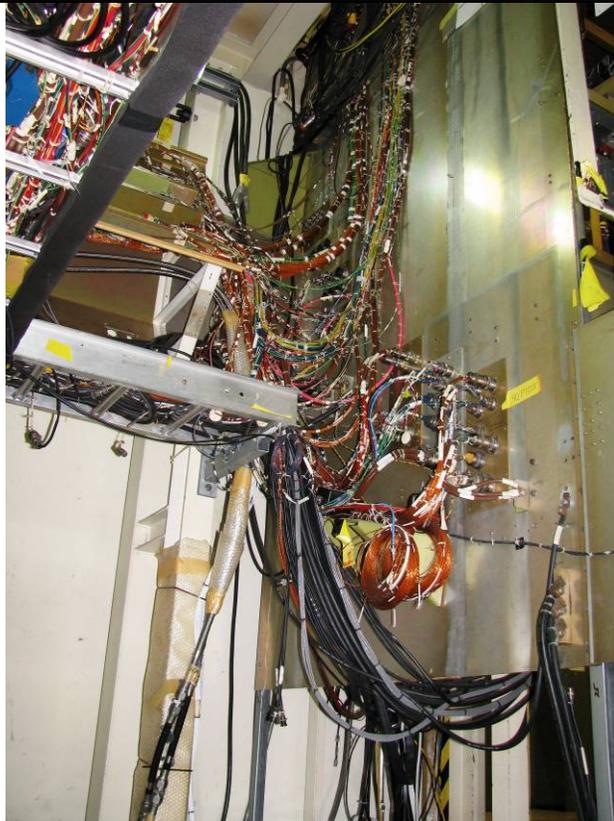
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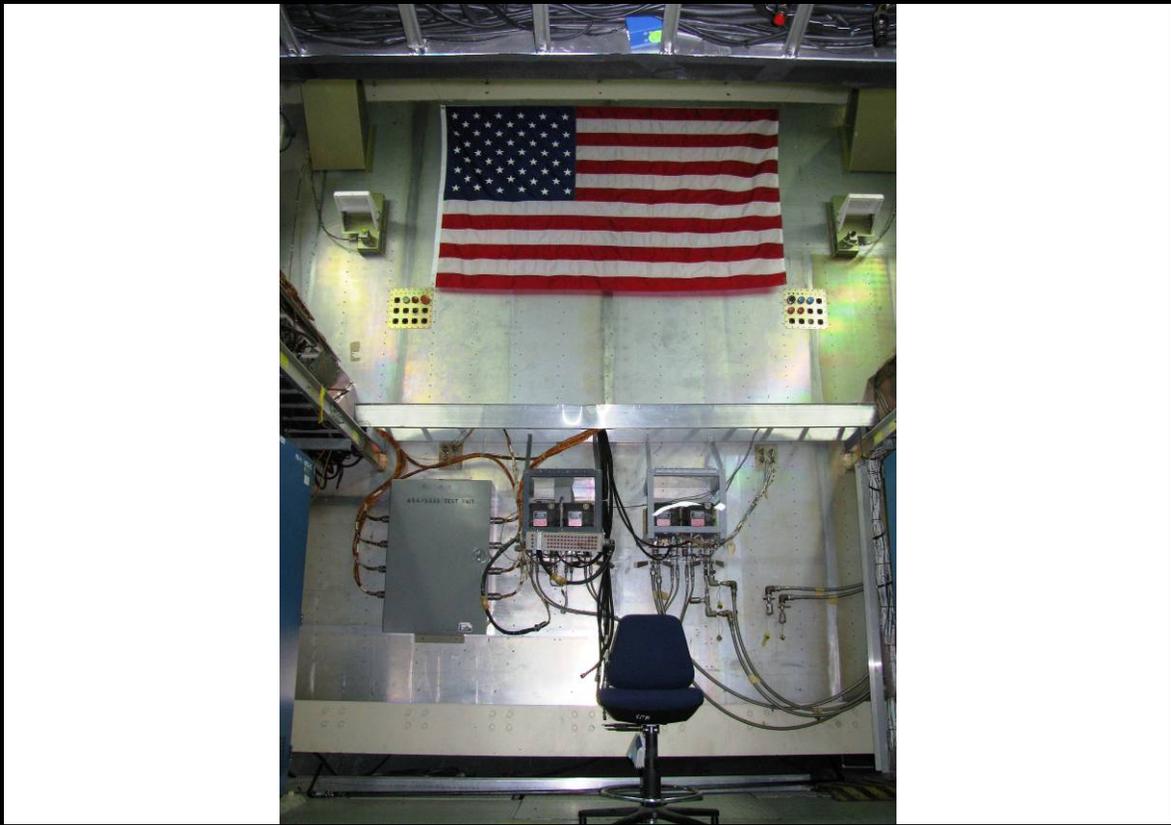
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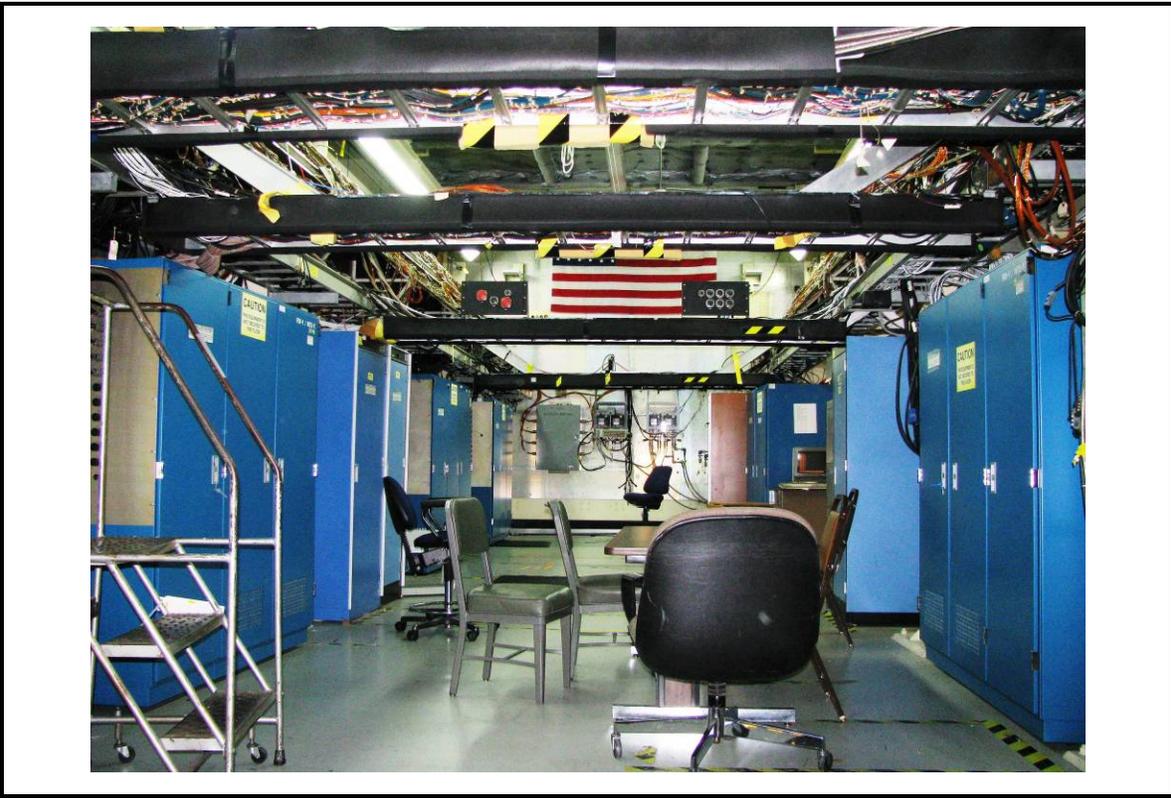
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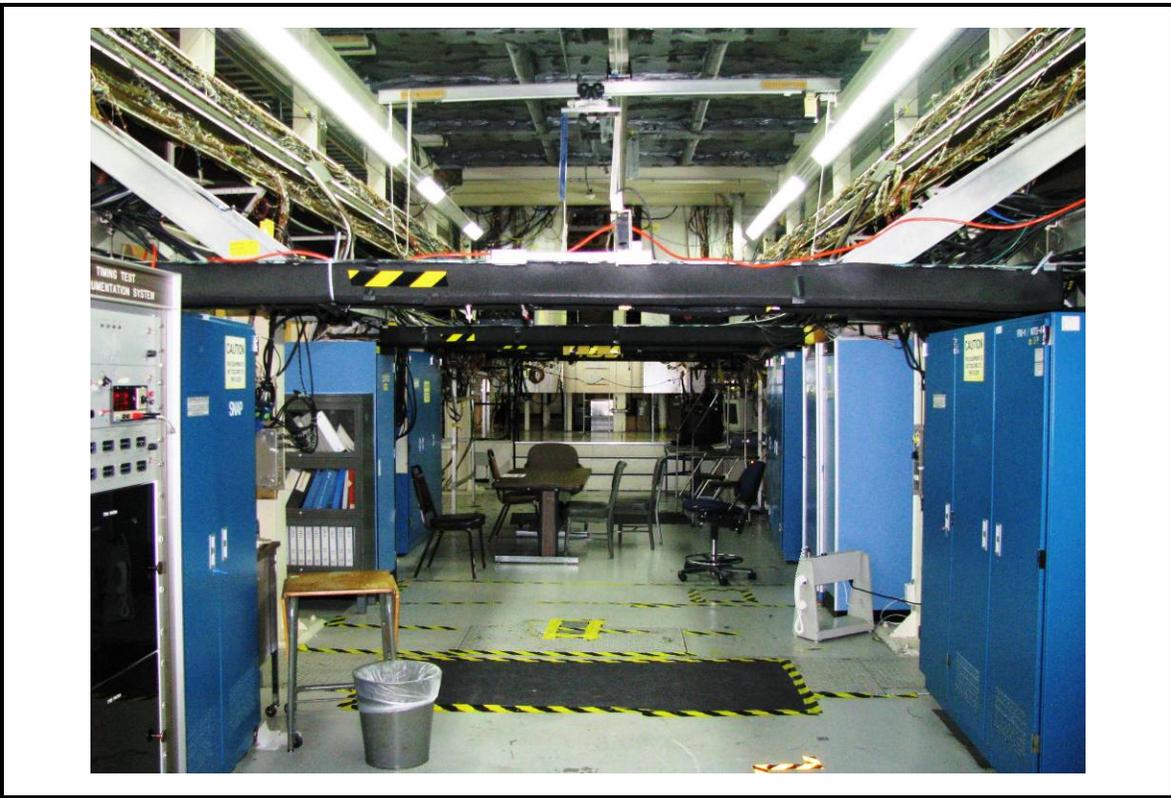
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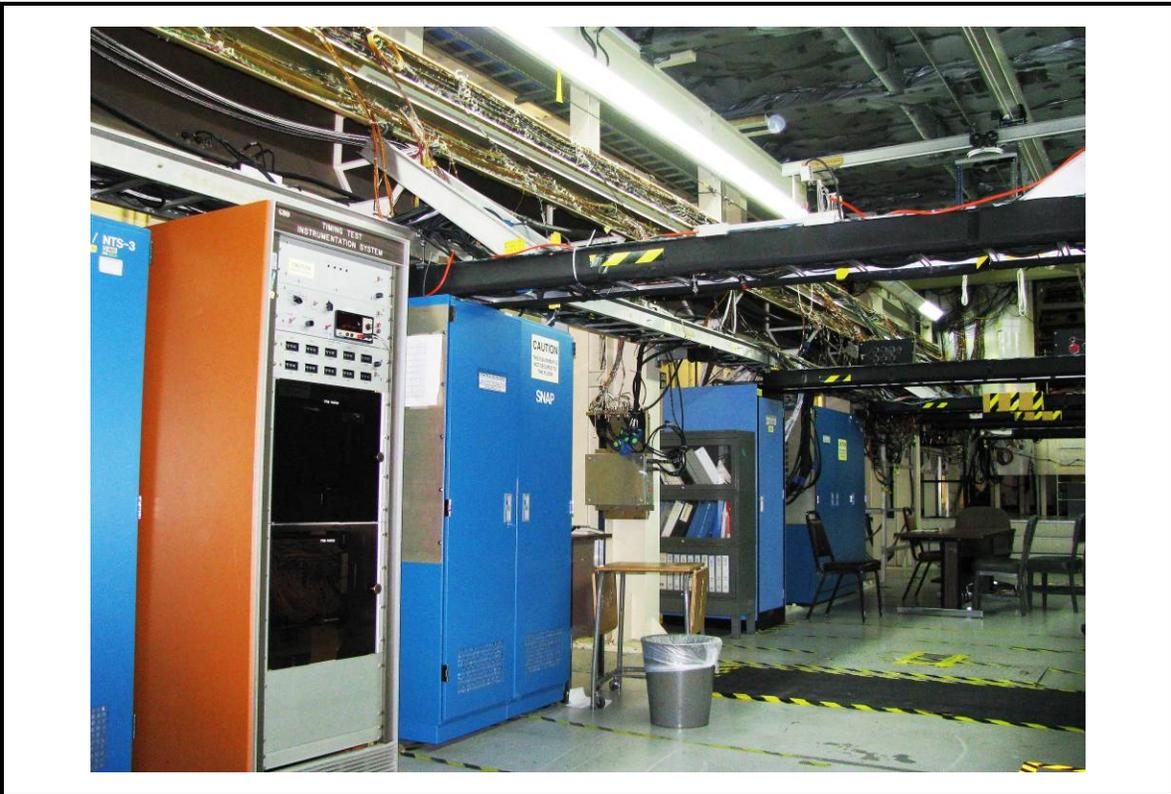
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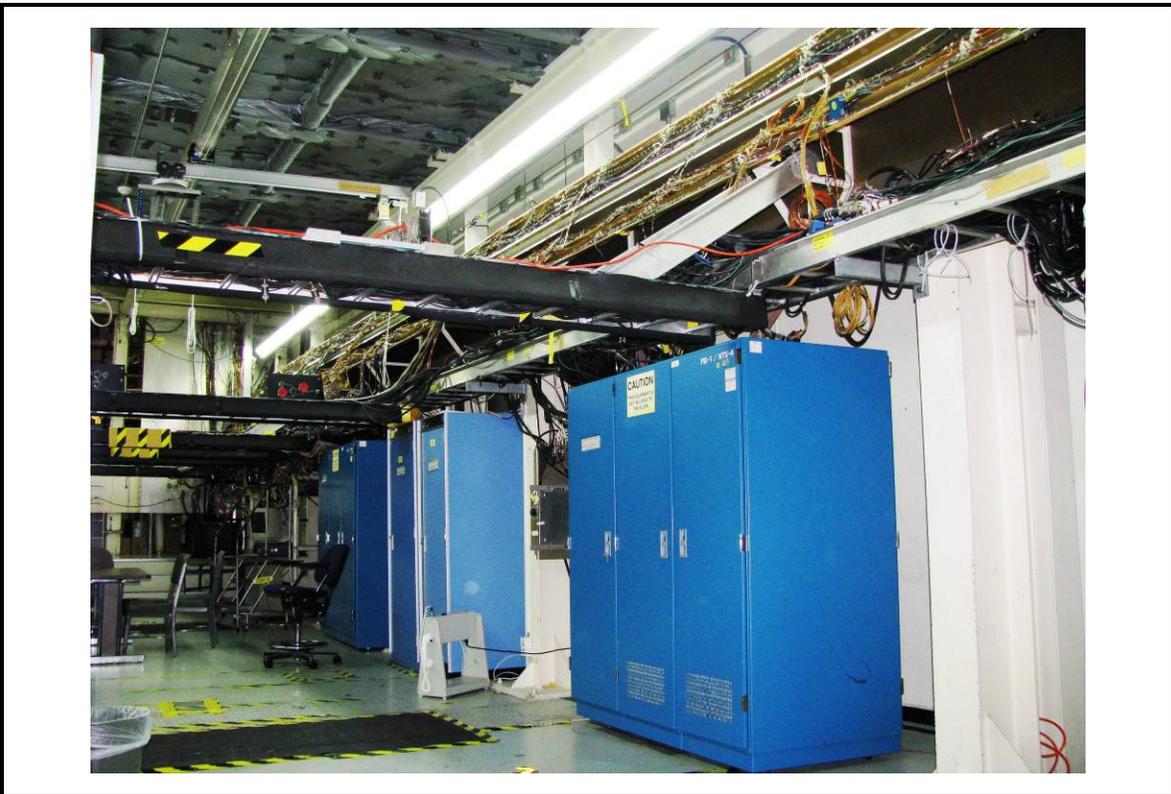
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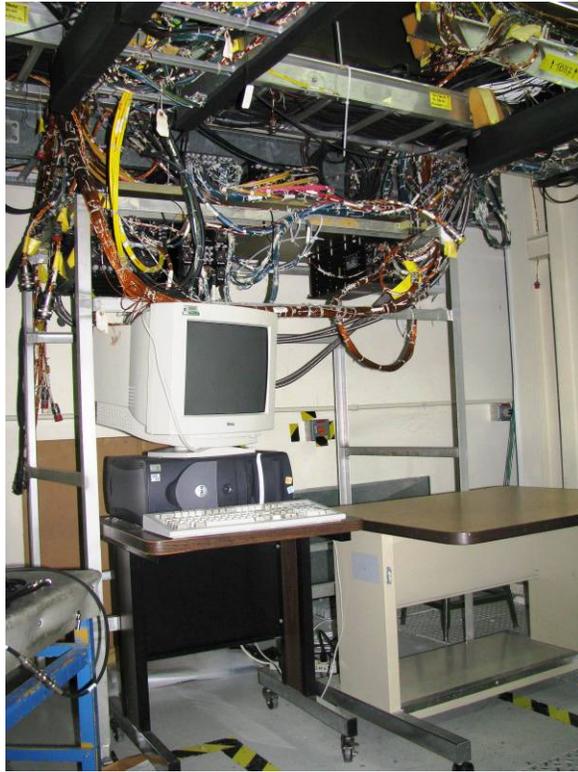
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ASL -45



ASL -46



ASL -47



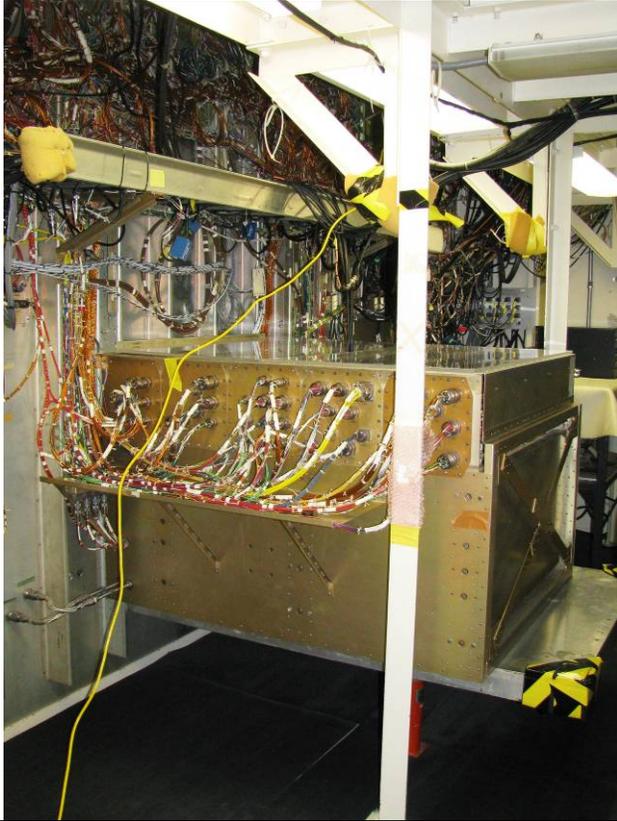
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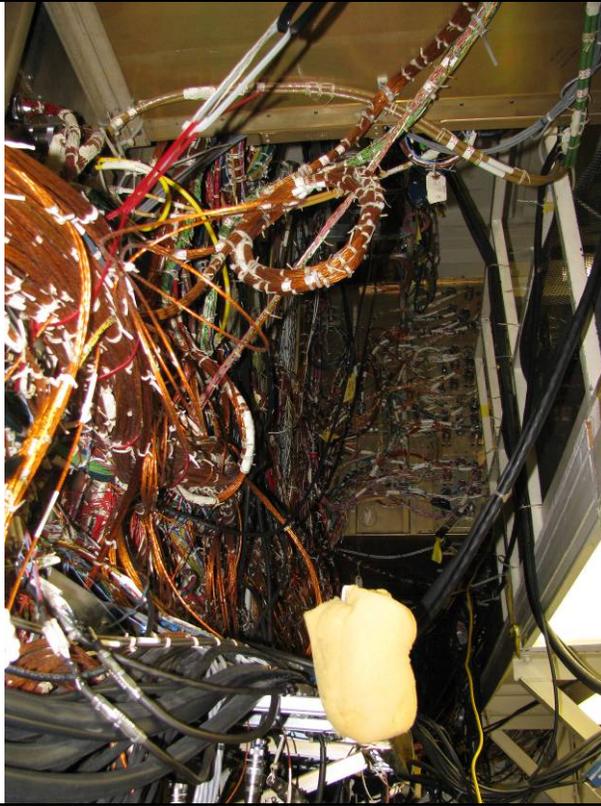
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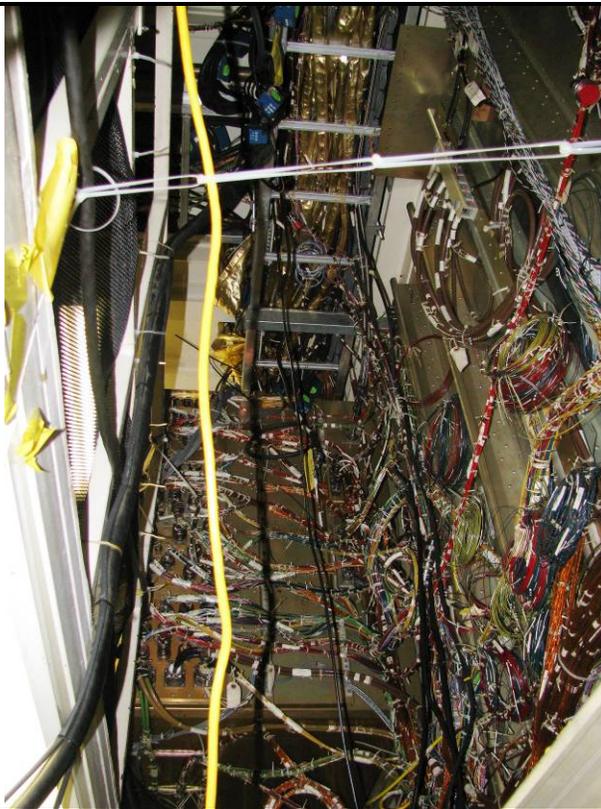
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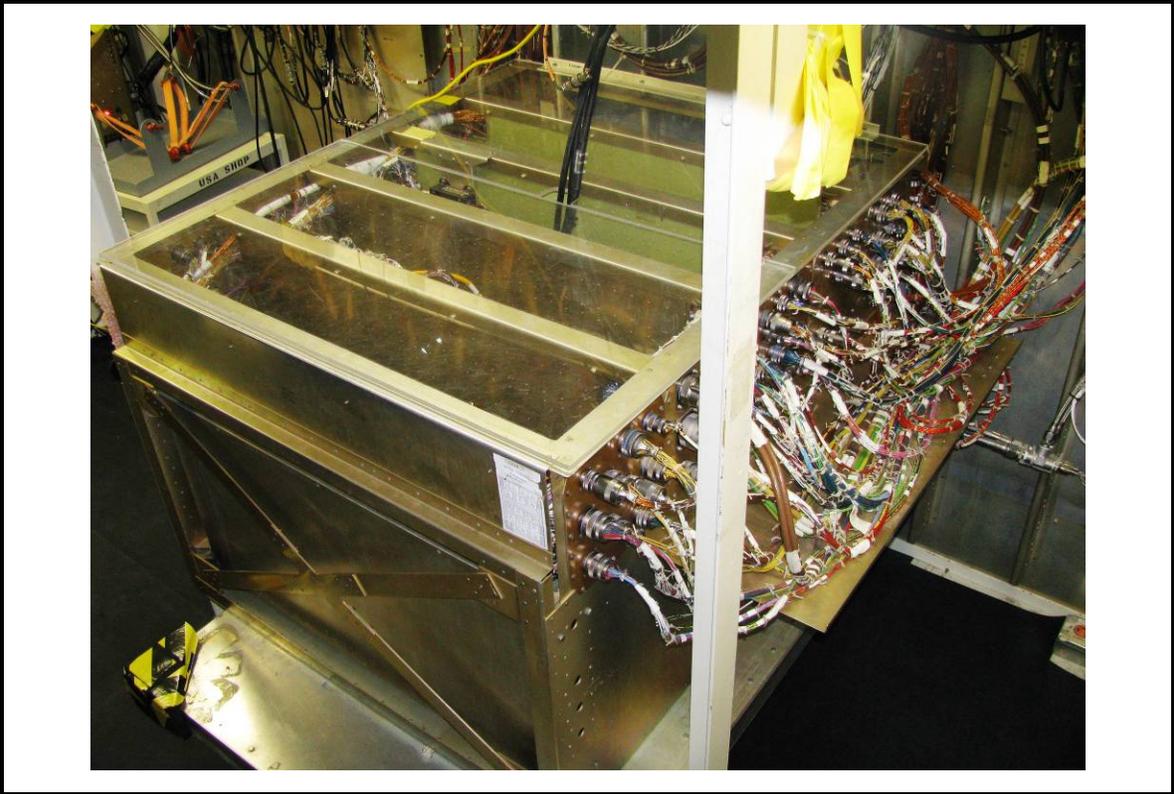
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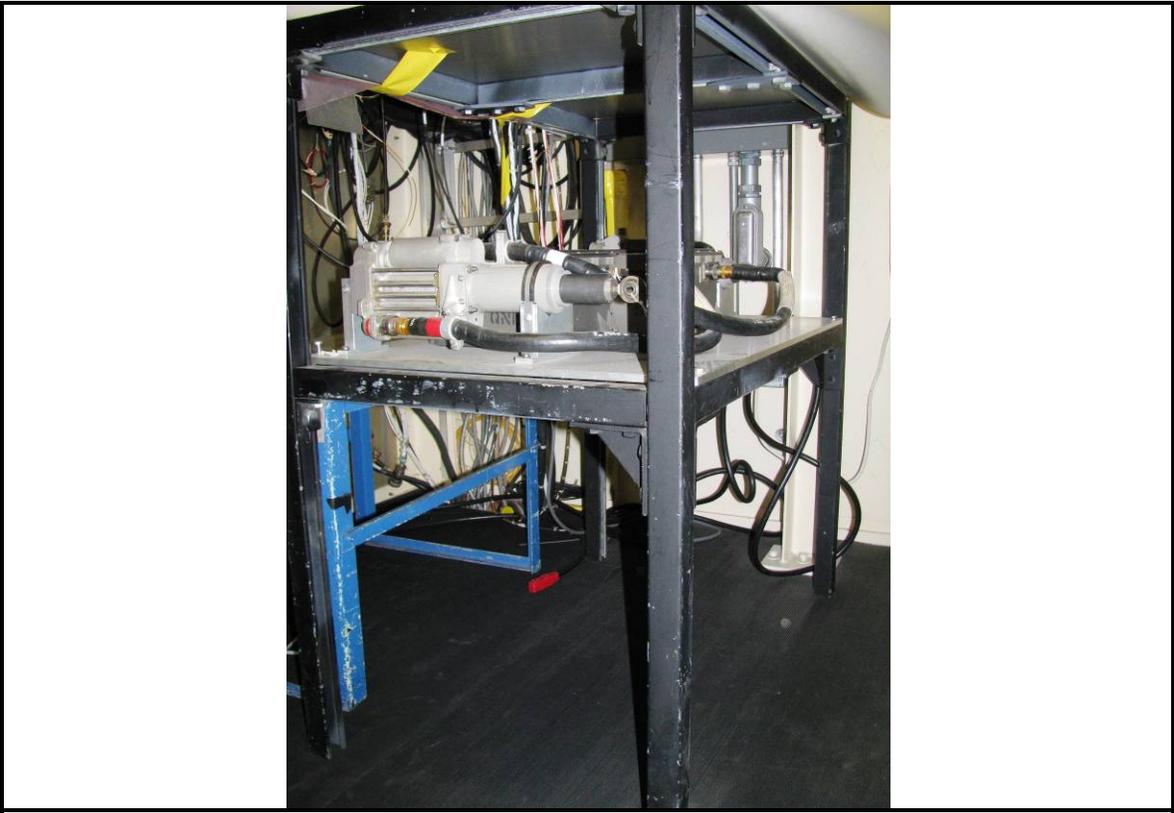
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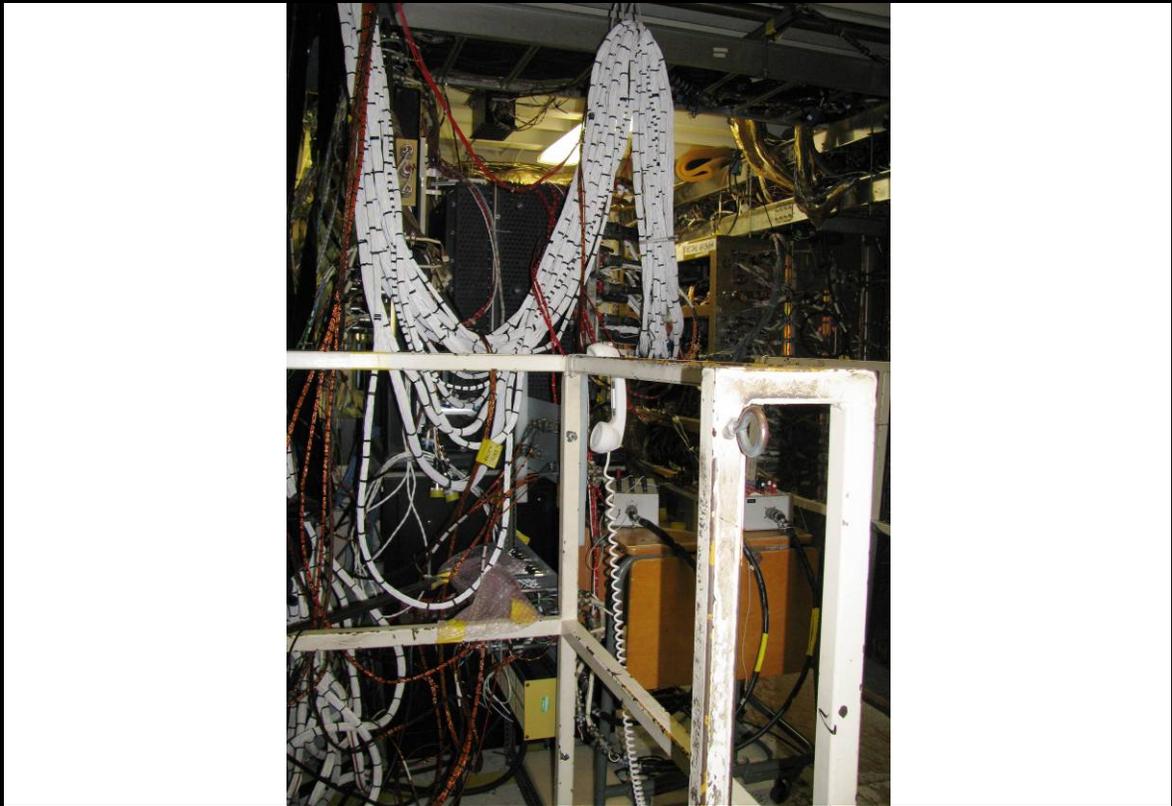
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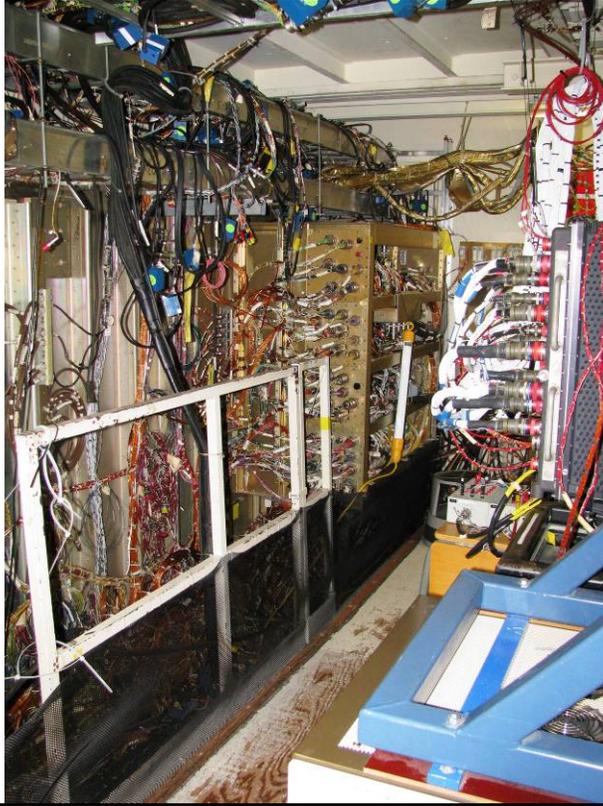
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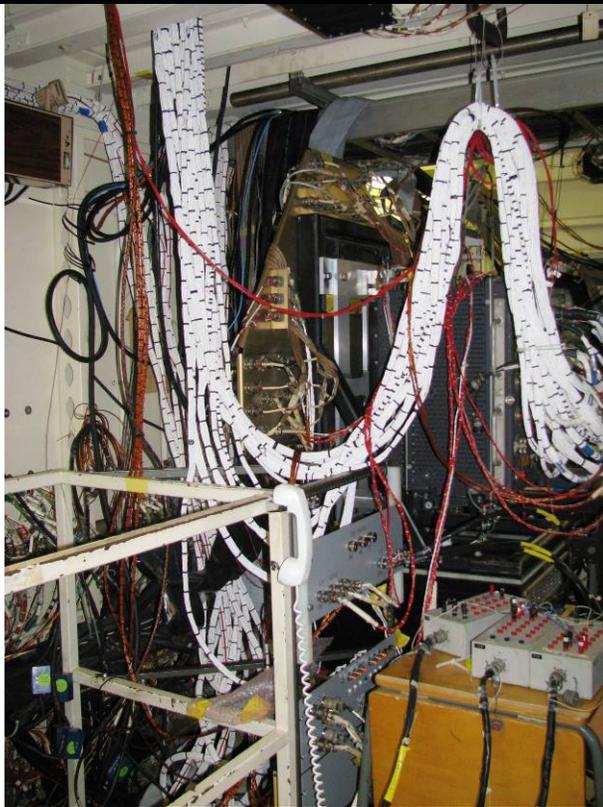
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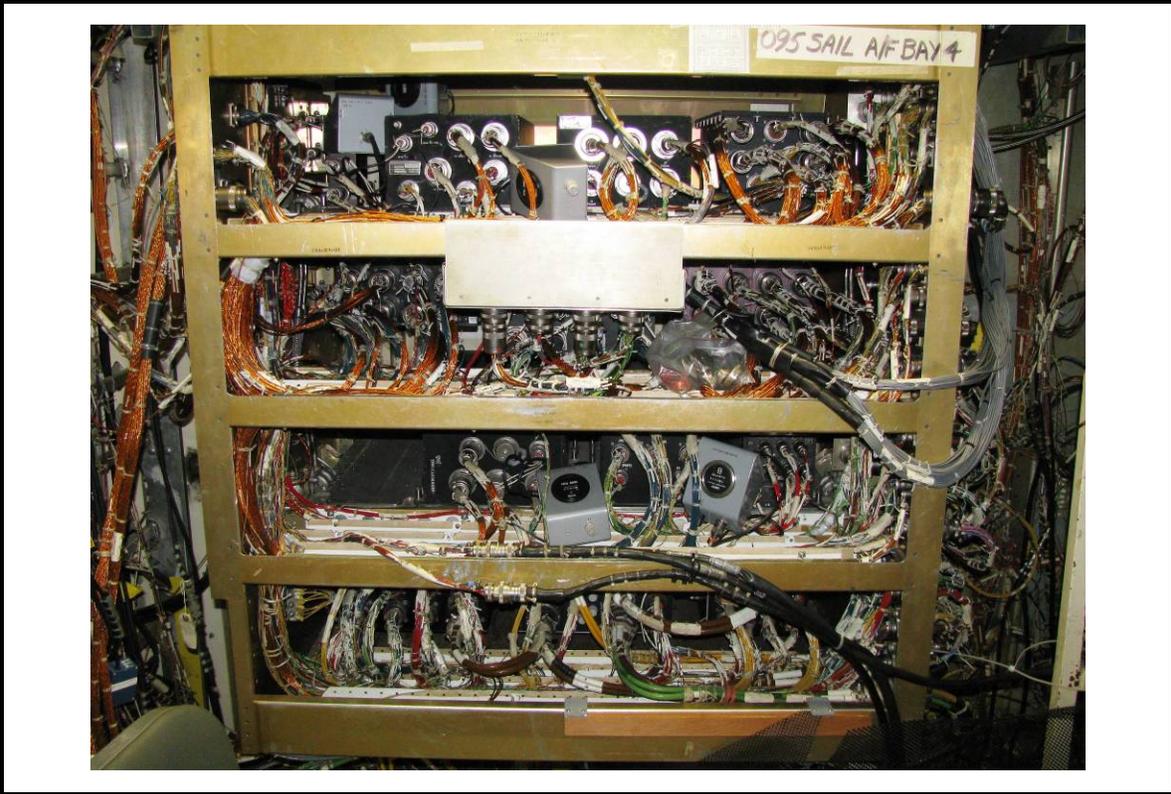
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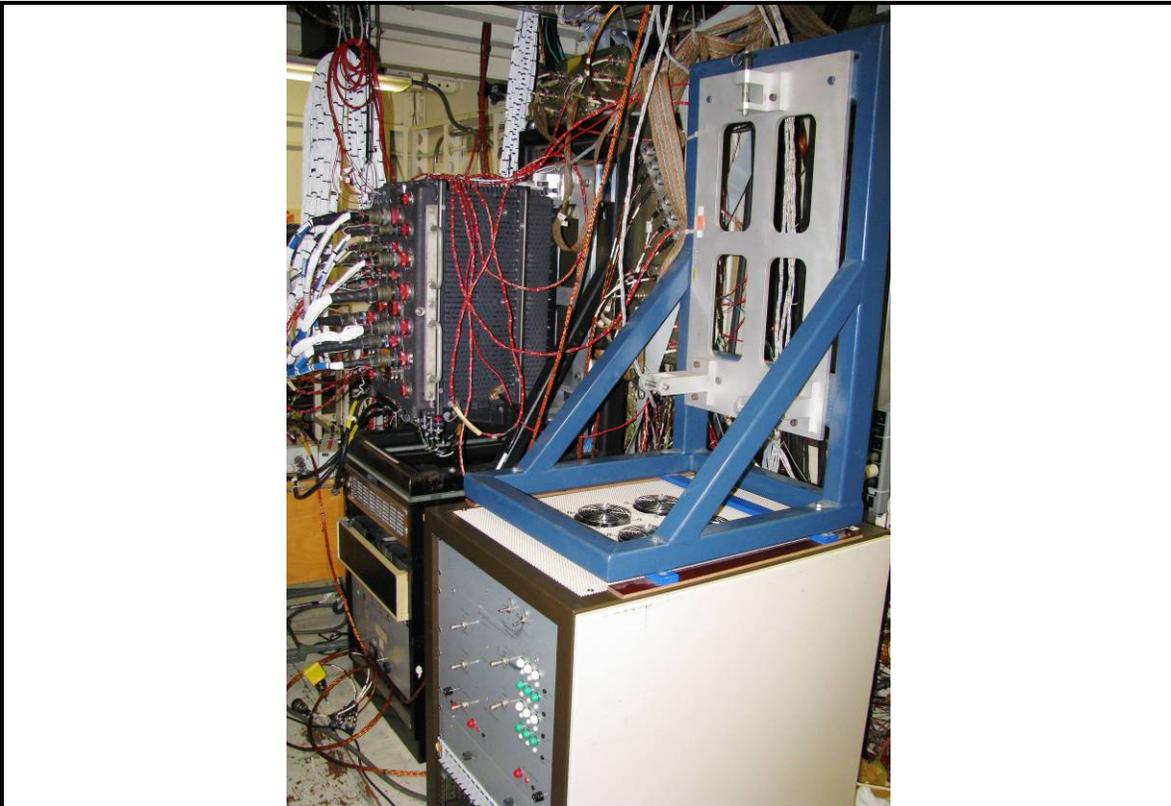
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ASL -60



ASL -61



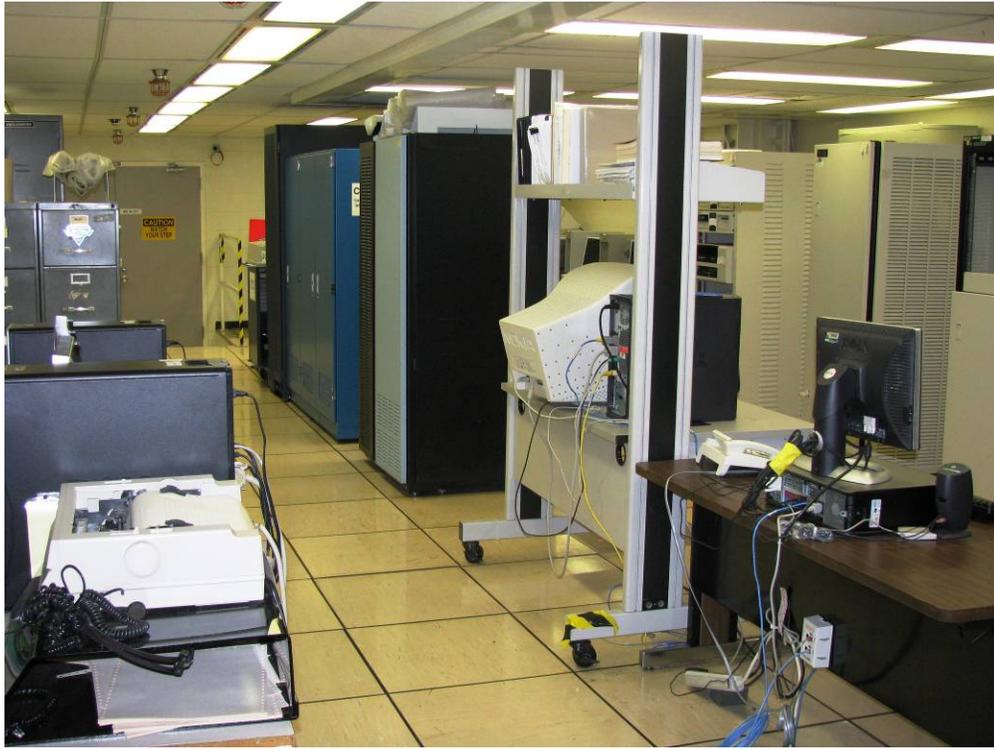
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ASL -63



ASL -64



ASL -65



ASL -66



ASL -67



ASL -68



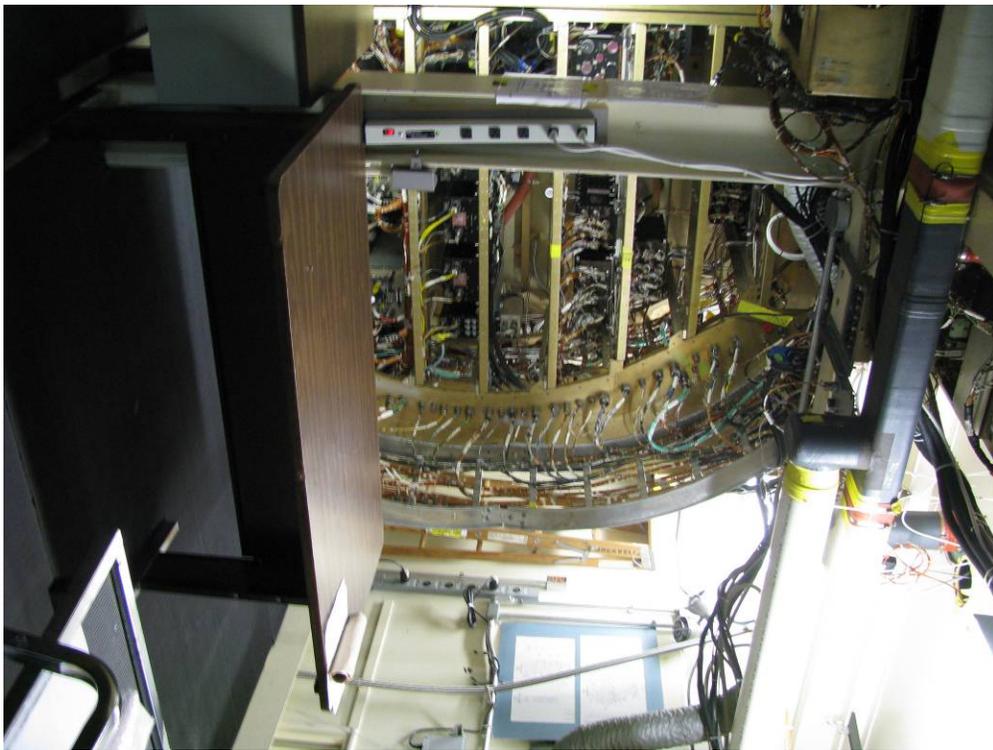
ASL -69



ASL -70



ASL -71



ASL -72



ASL -73



ASL -74



ASL -75



ASL -76



ASL -77



ASL -78



ASL -79



ASL -80



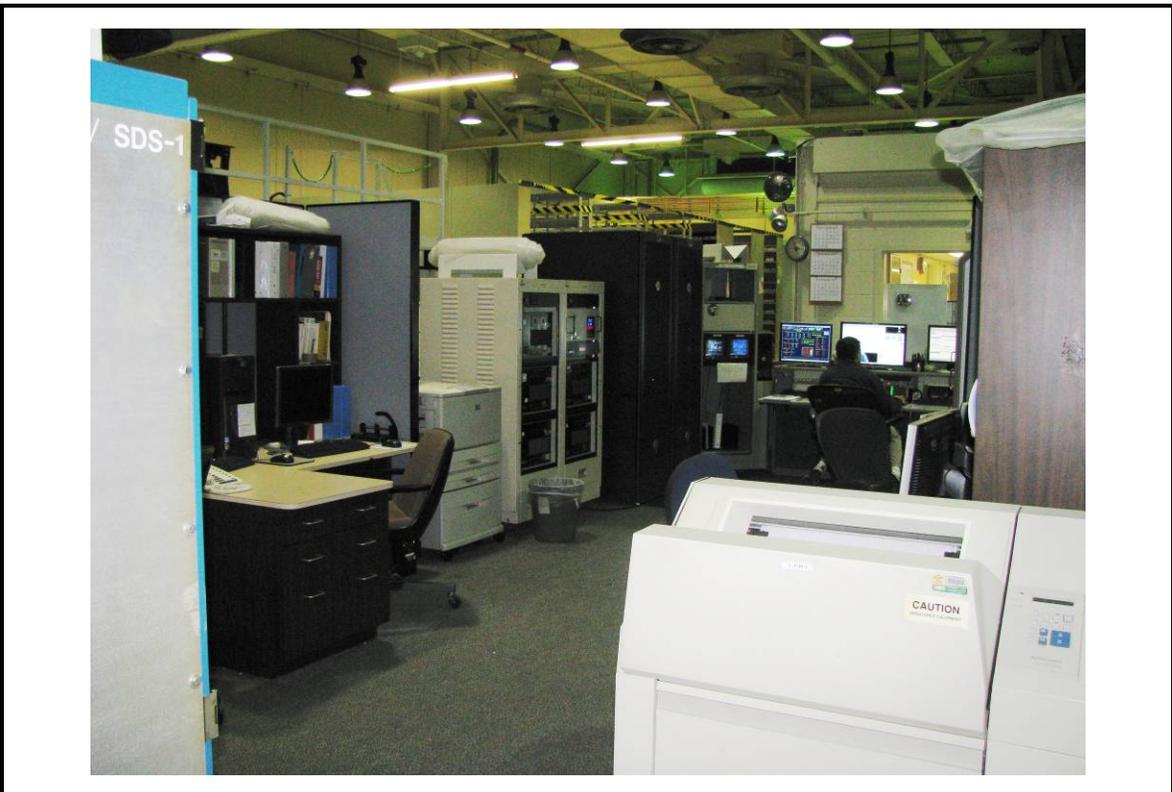
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ASL -82



ASL -83



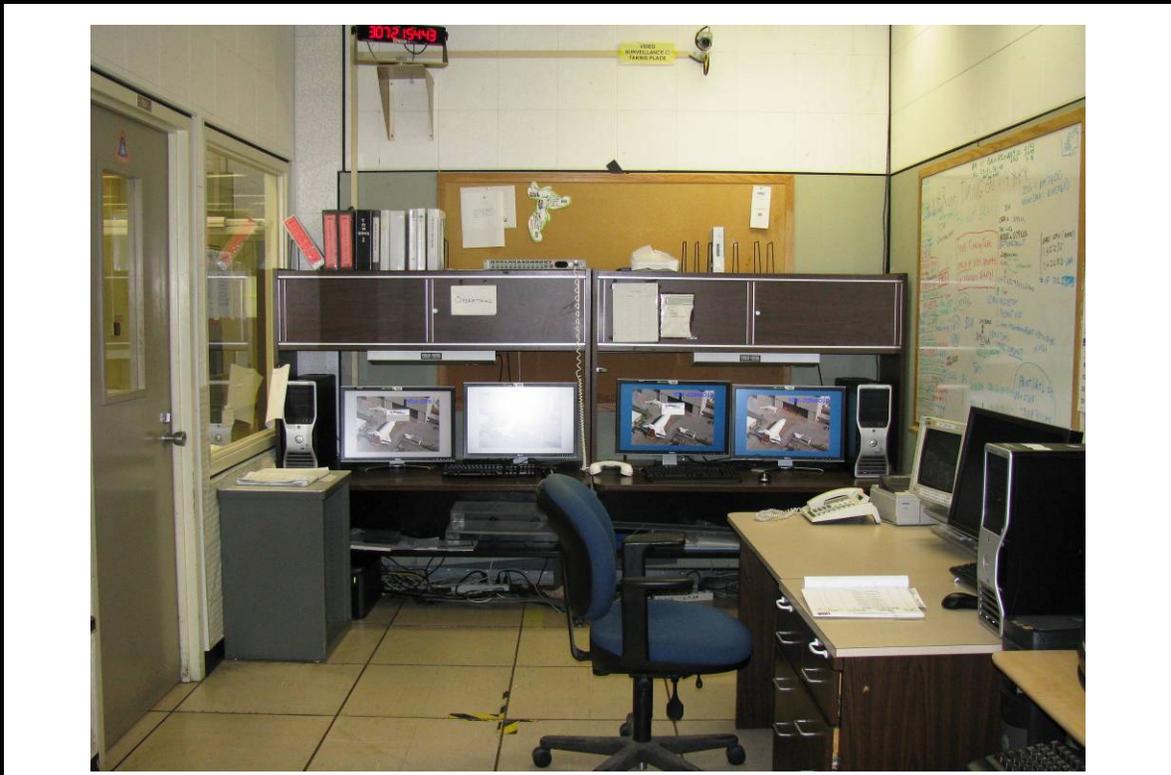
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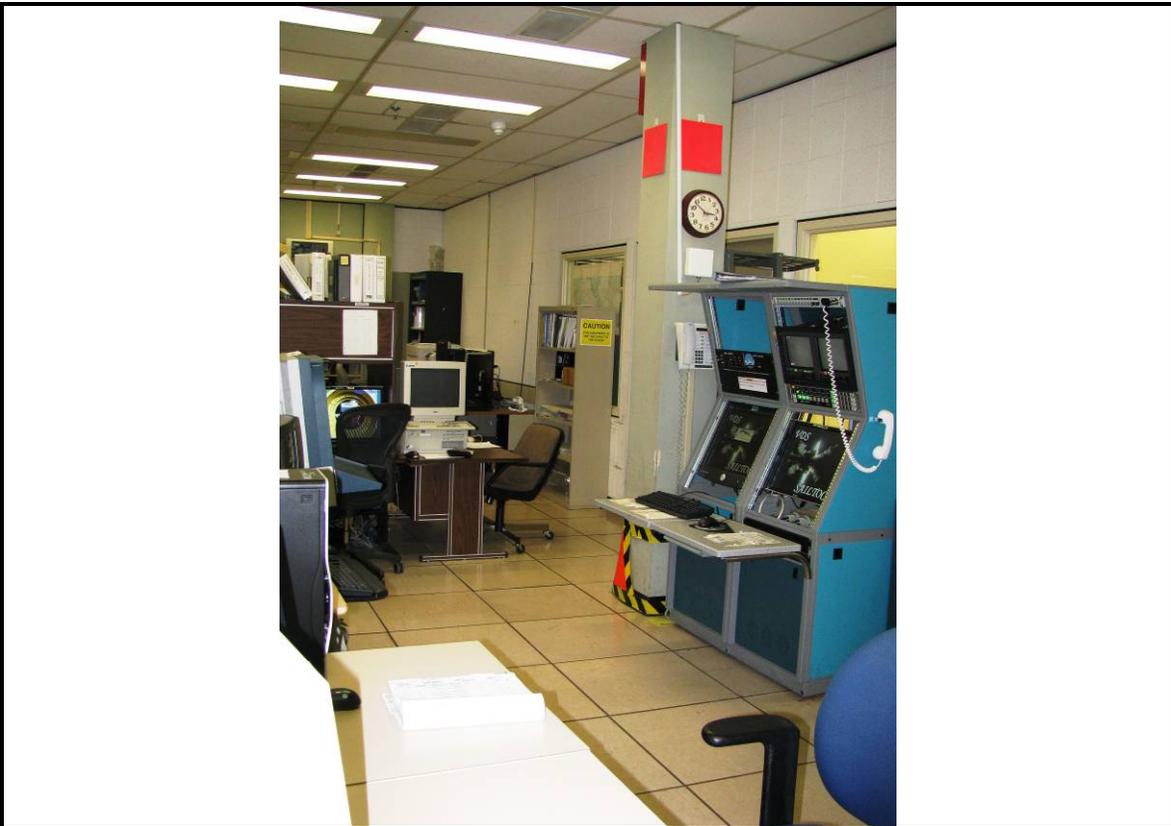
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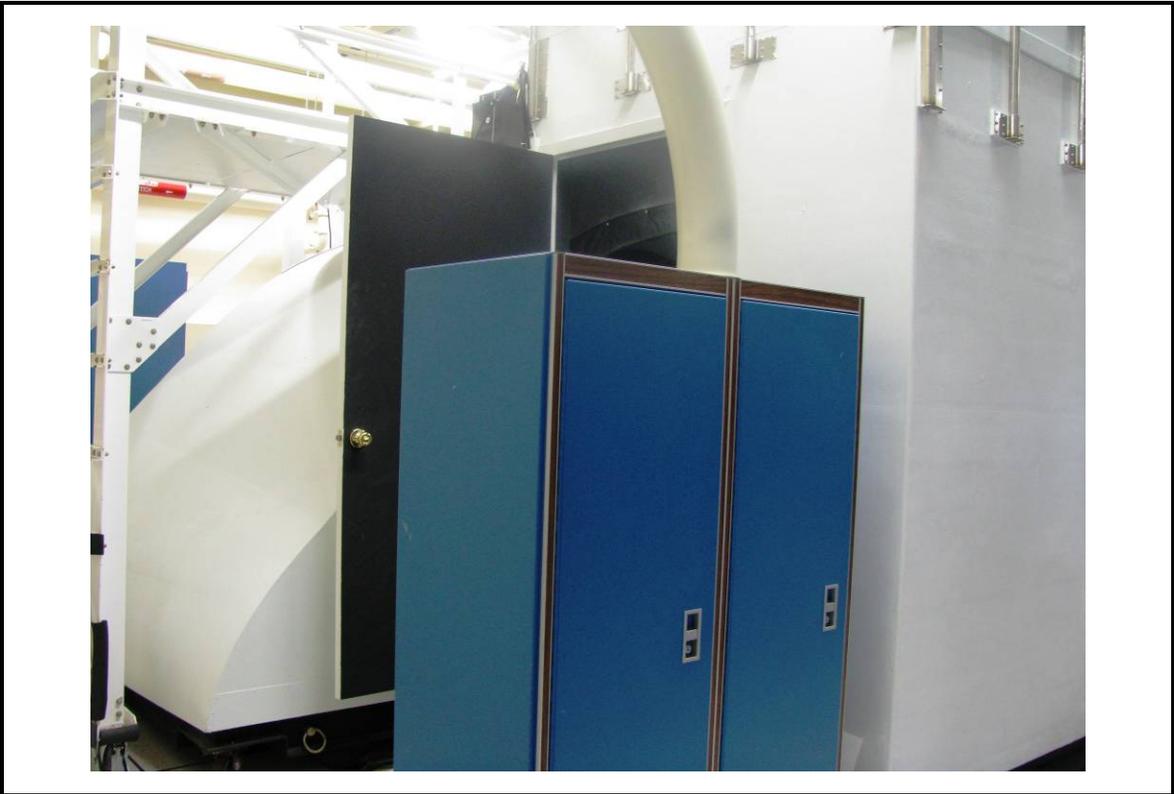
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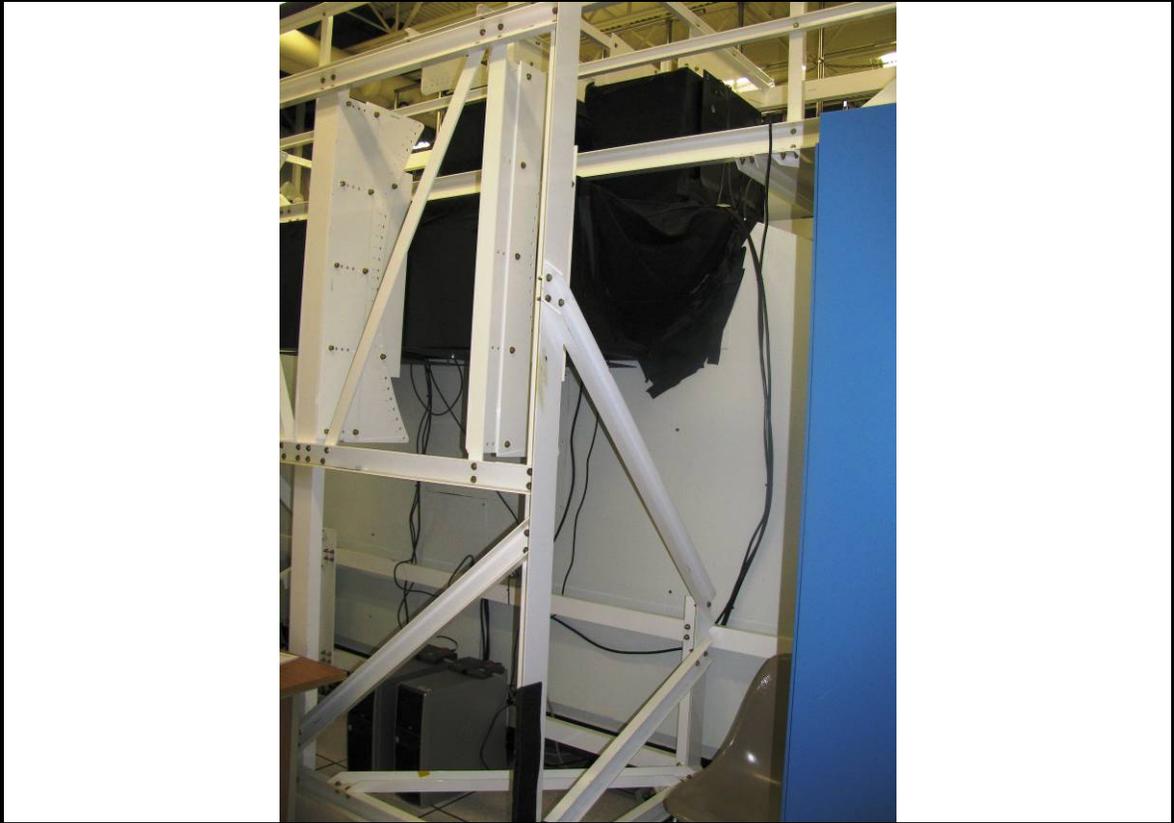
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ASL -90



ASL -91



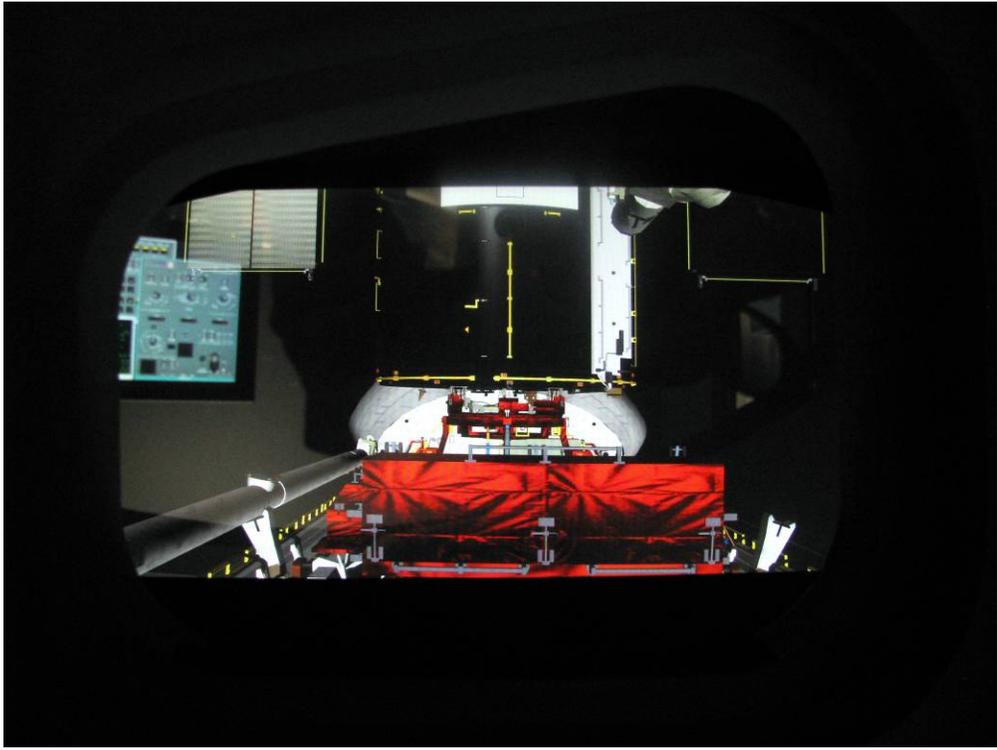
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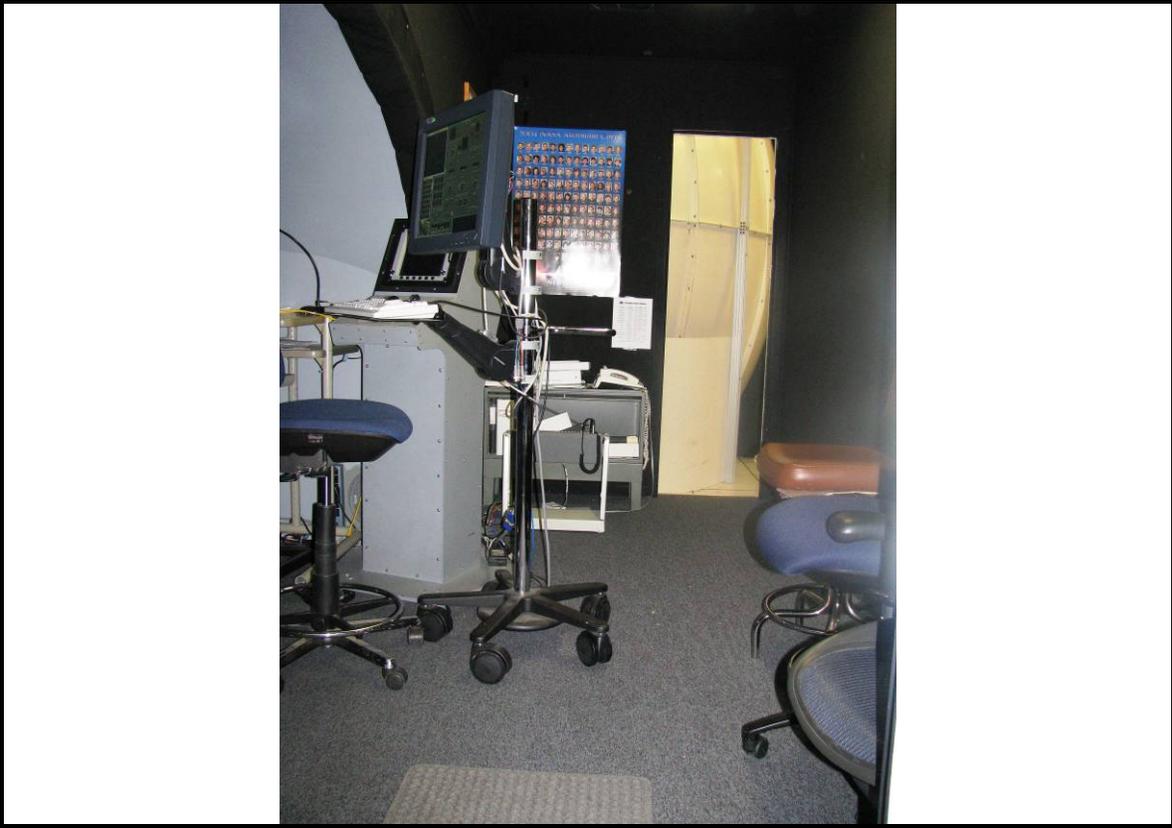
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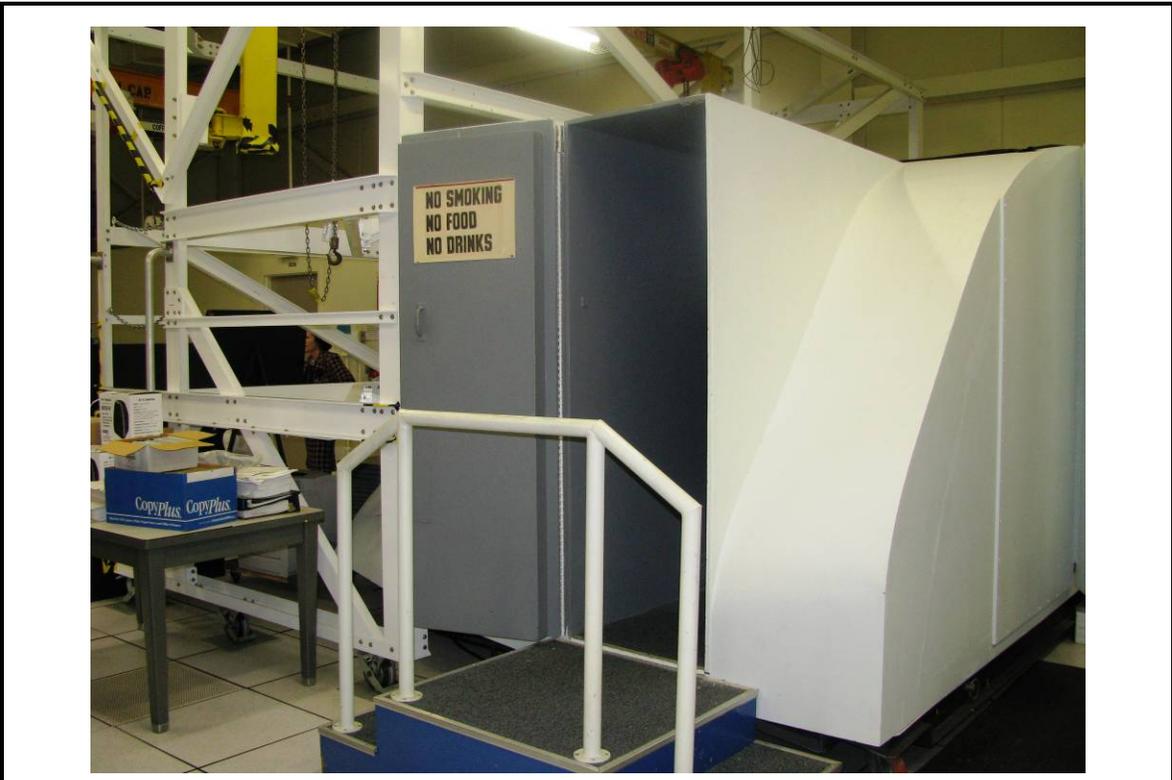
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ASL -97



ASL -98



ASL -99



ASL -100



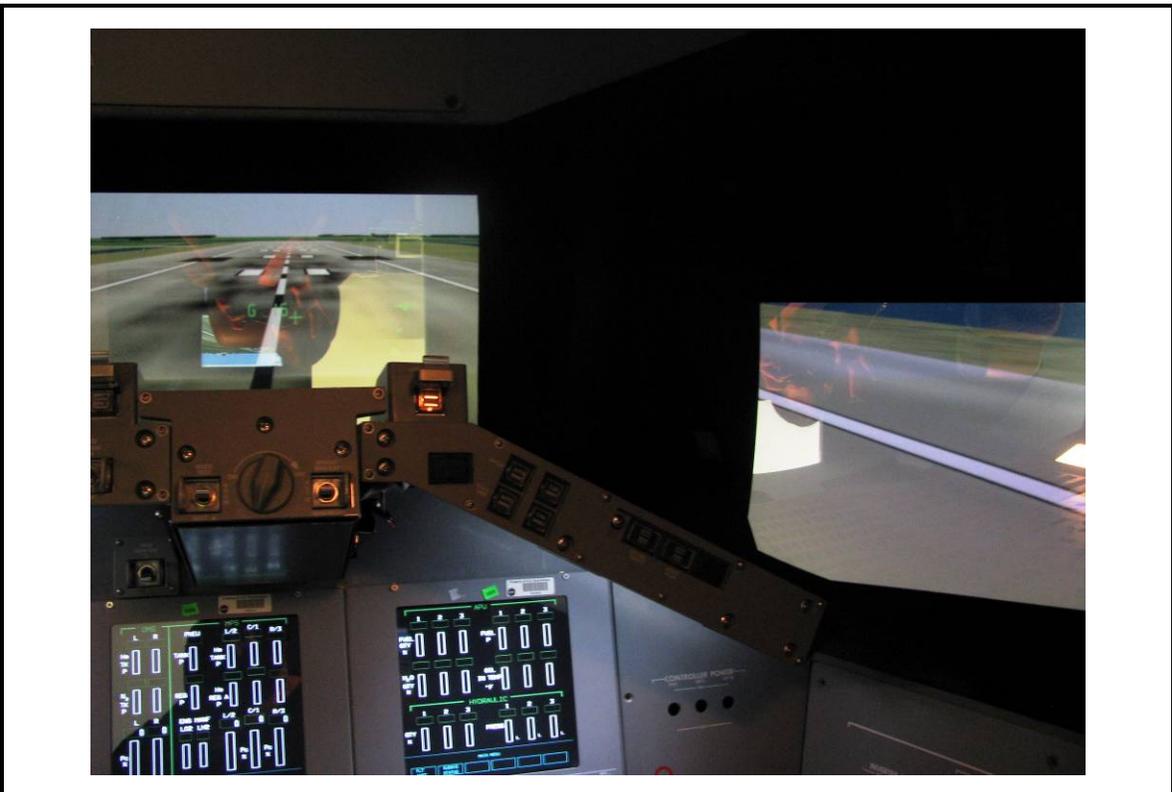
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ASL -103



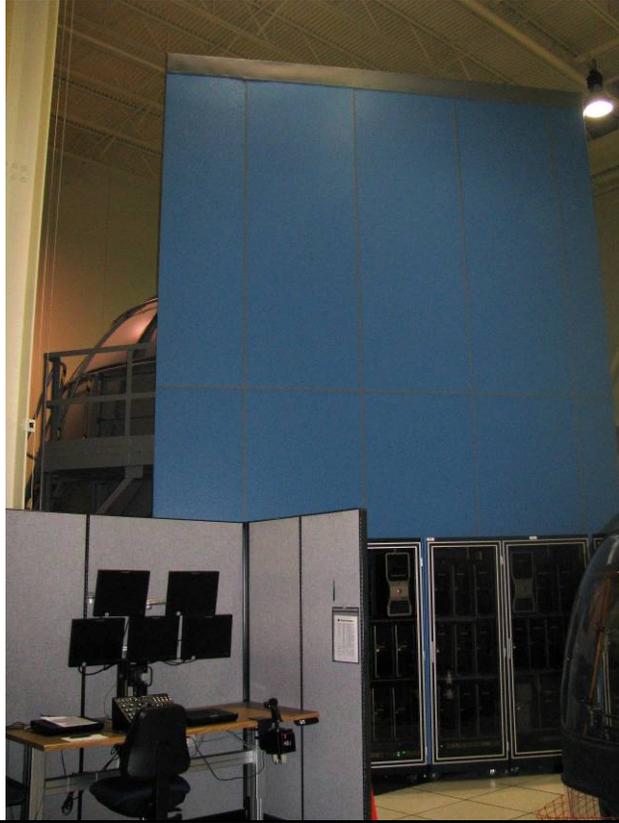
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ASL -106



ASL -107



ASL -108



ASL -109



ASL -110



ASL -111



ASL -112



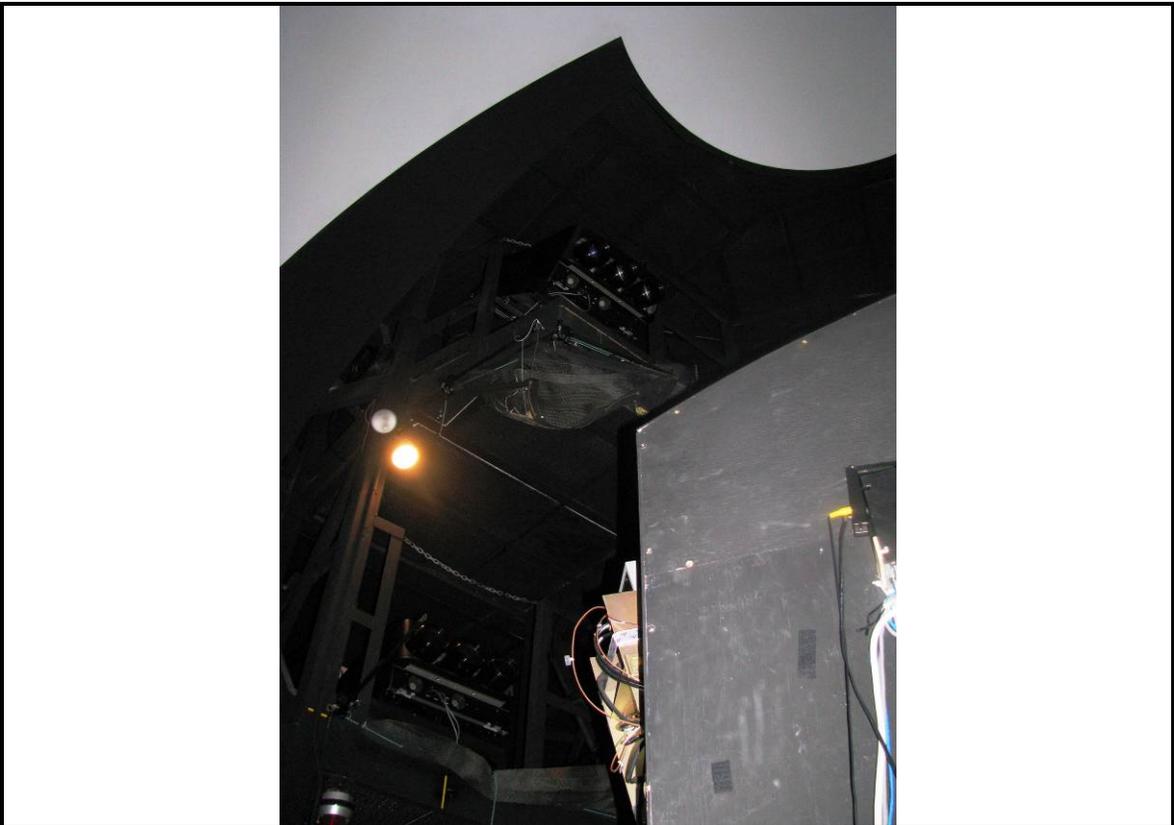
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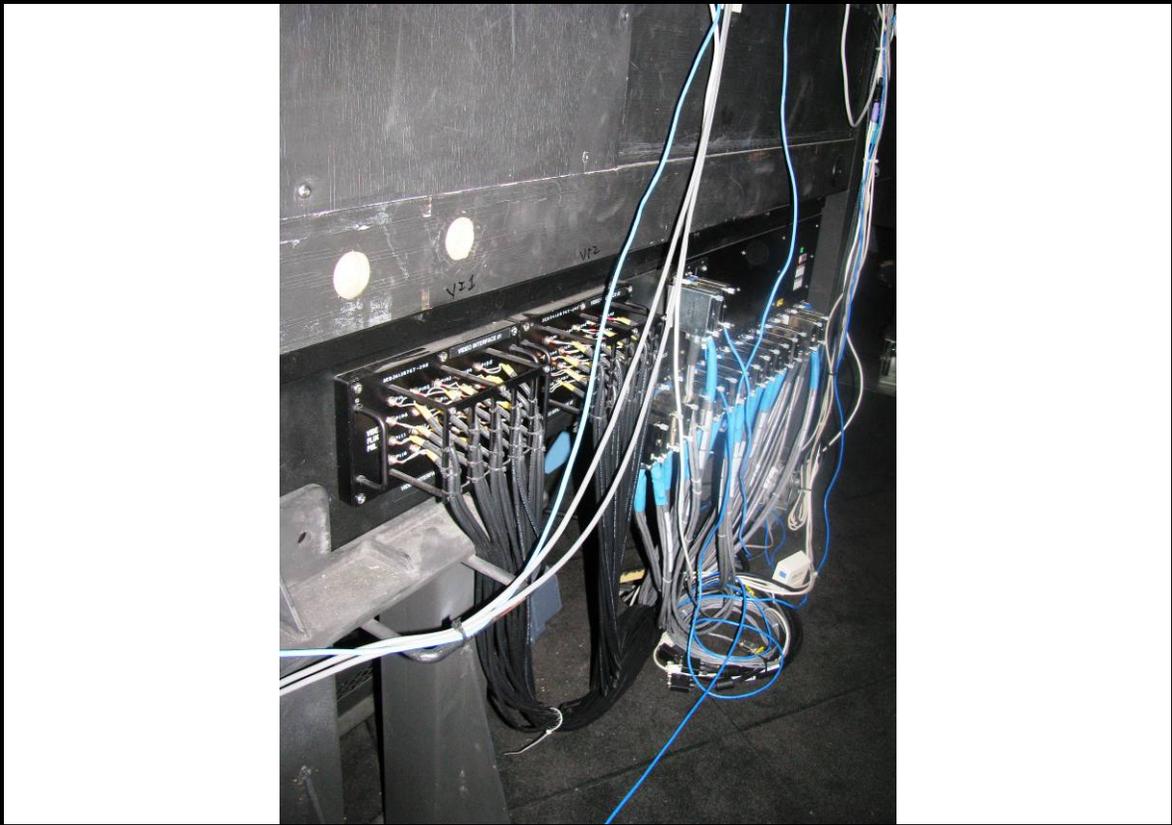
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ASL -116



ASL -117



ASL -118



ASL -119



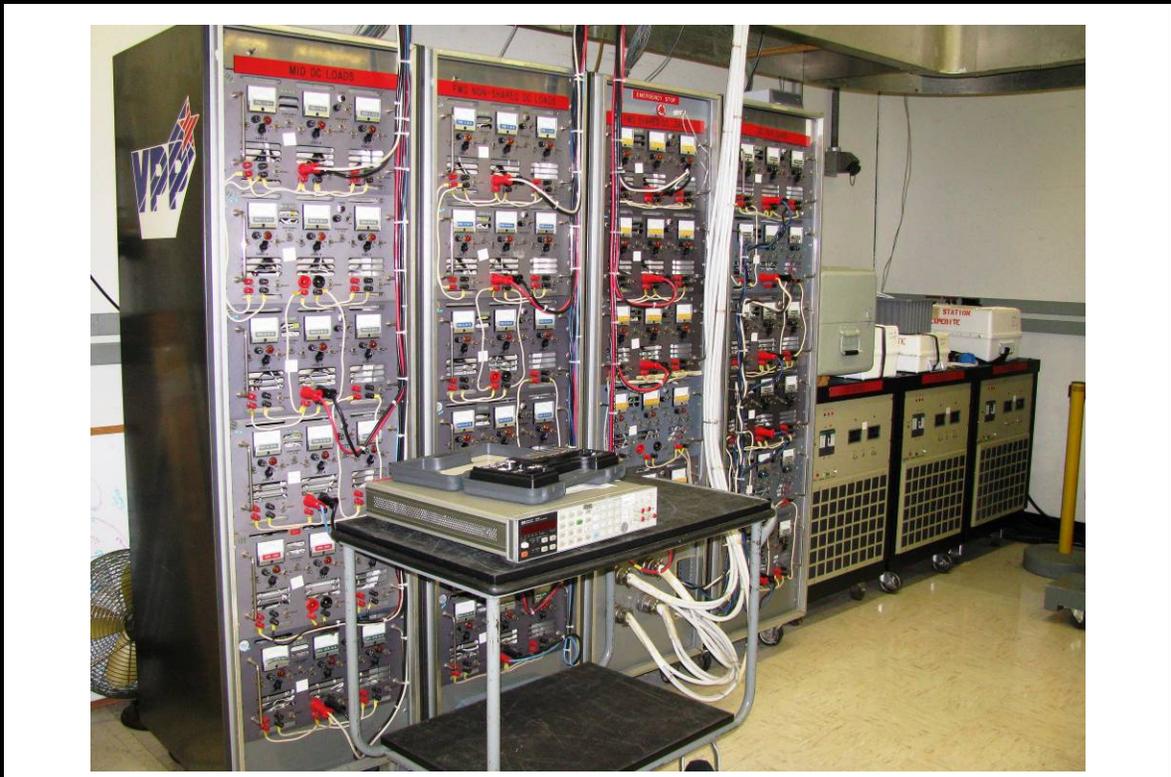
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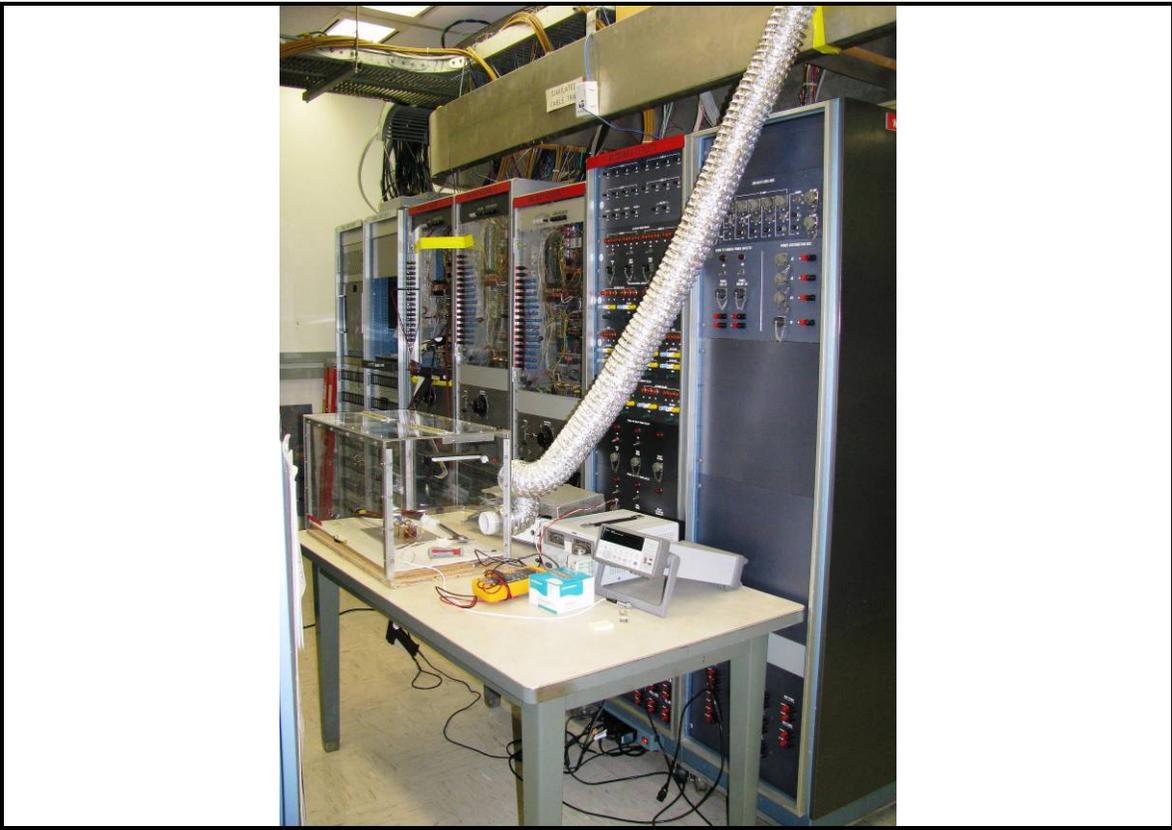
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ASL -123



ASL -124



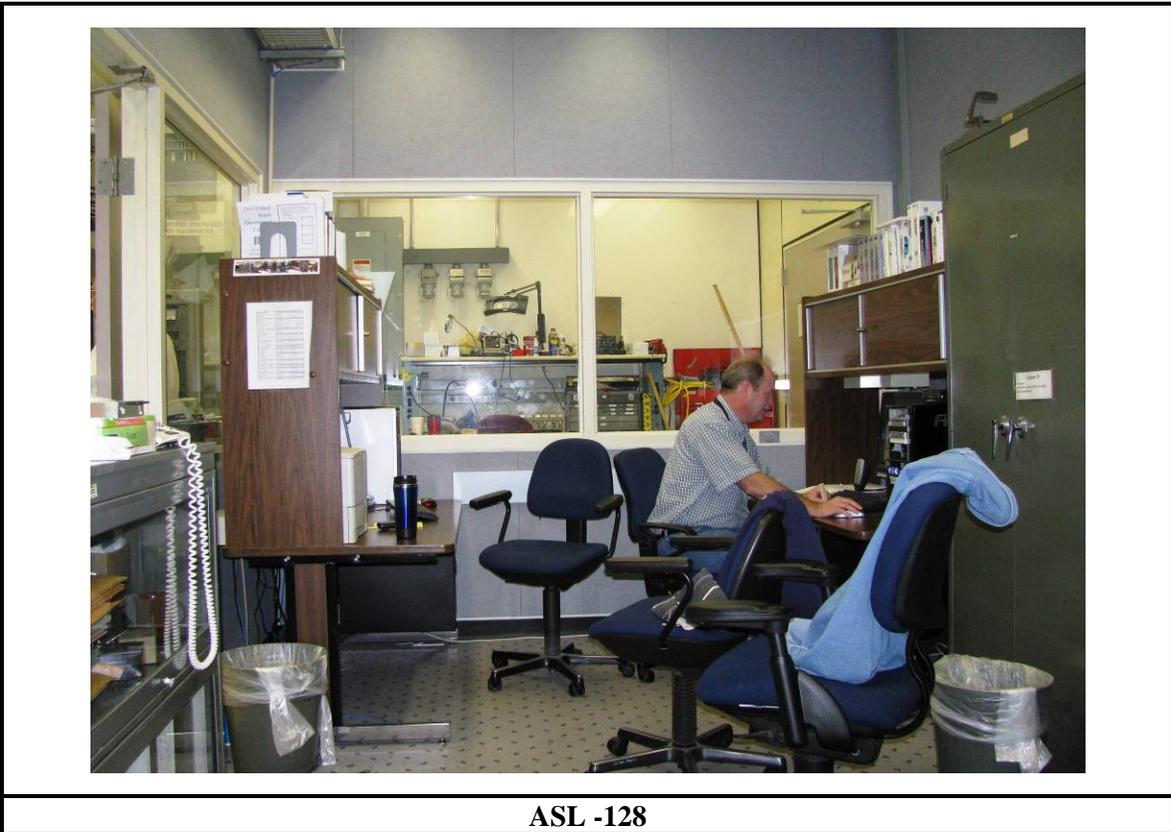
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ASL -126



ASL -127



ASL -128



ASL -129



ASL -130



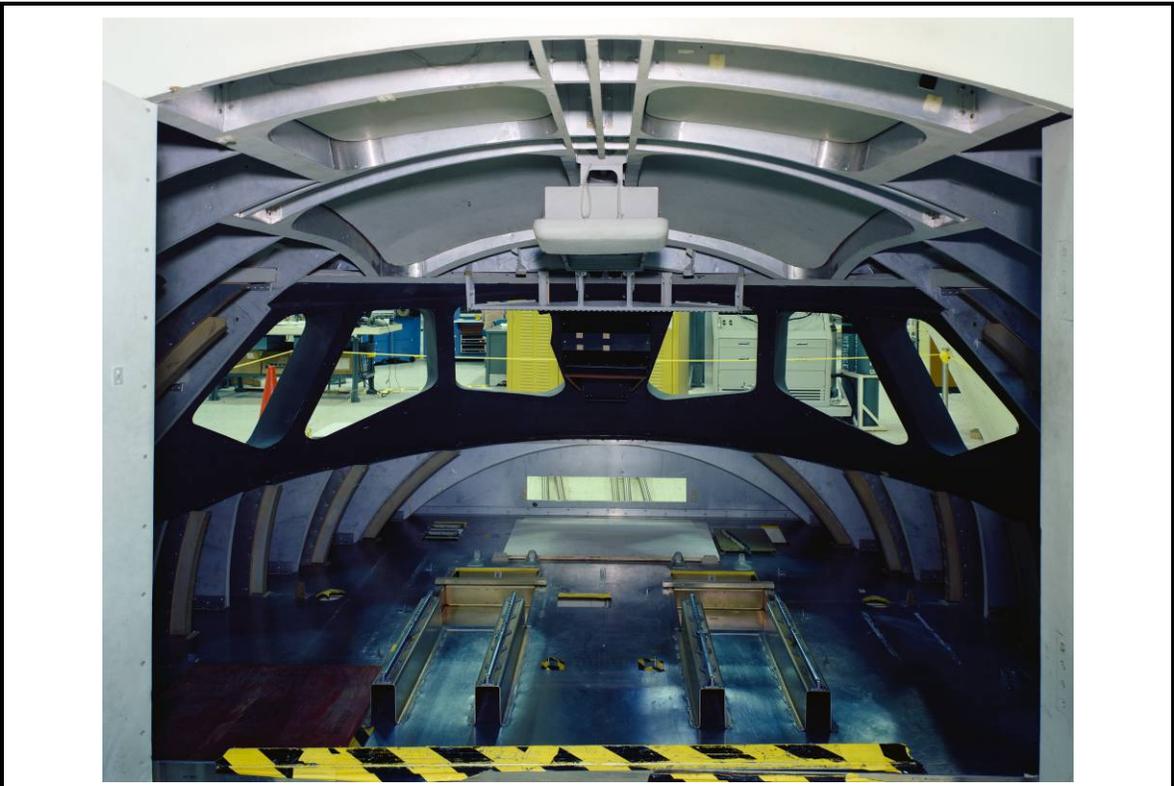
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ASL -132



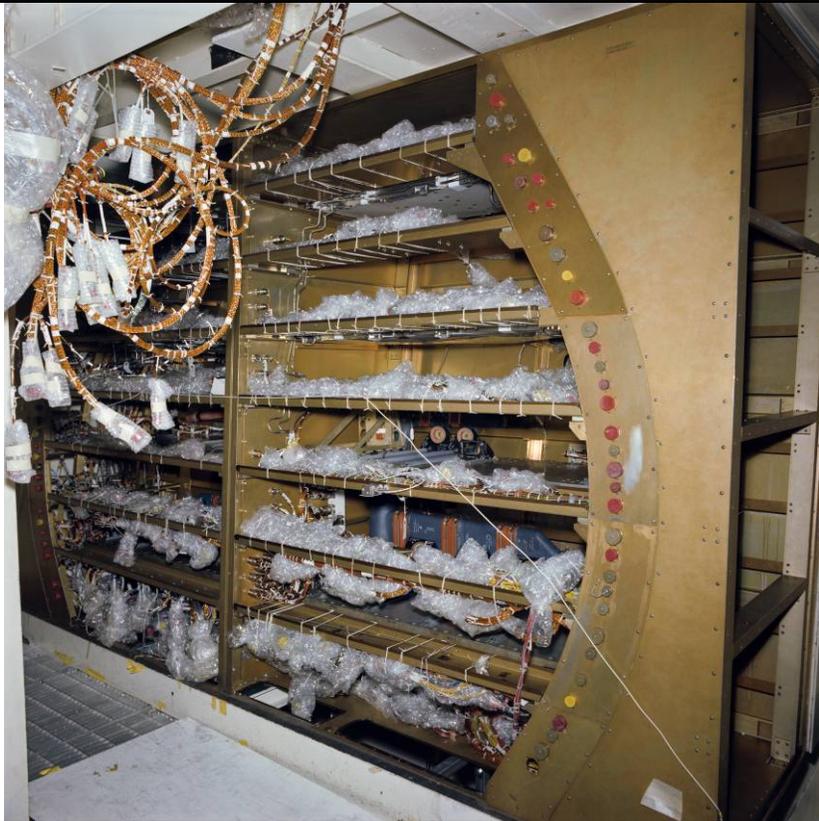
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ASL -134



ASL -135



ASL -136



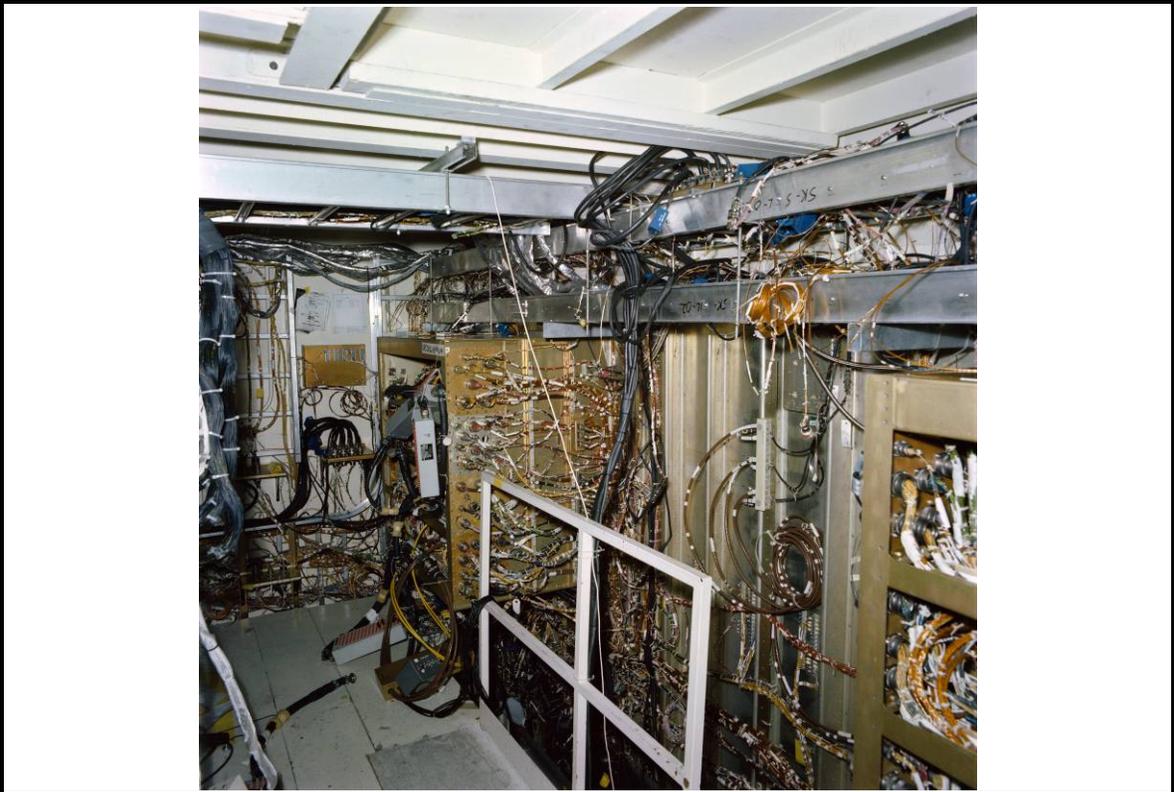
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ASL -140



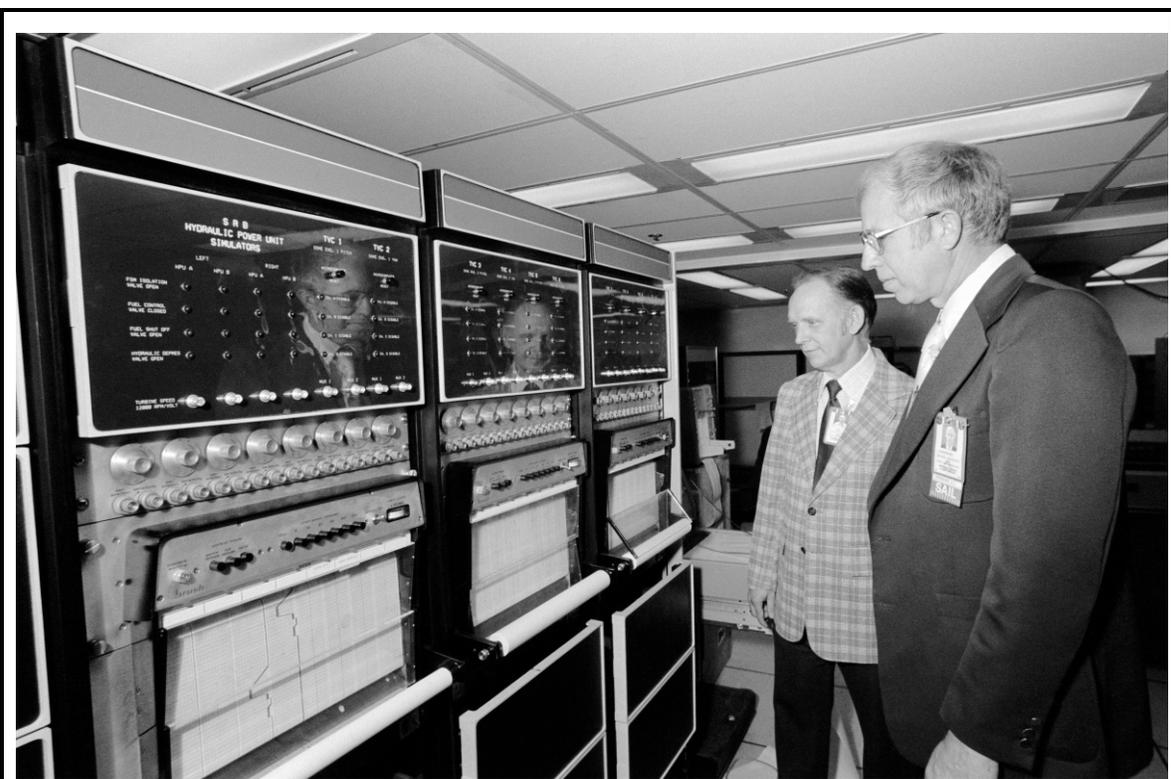
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ASL -142



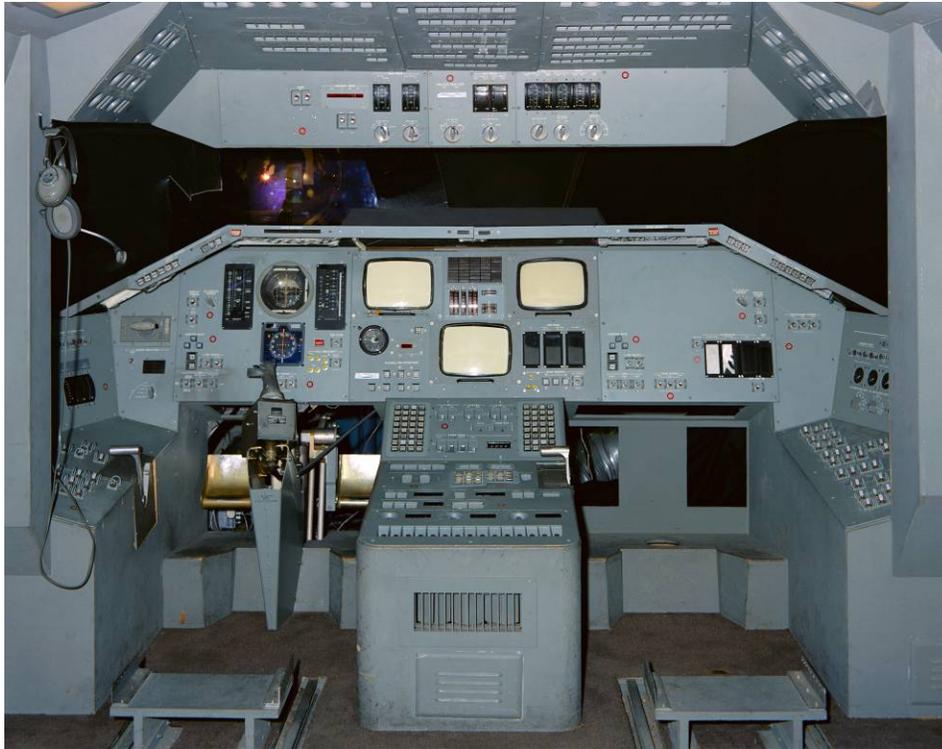
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ASL -144



ASL -145



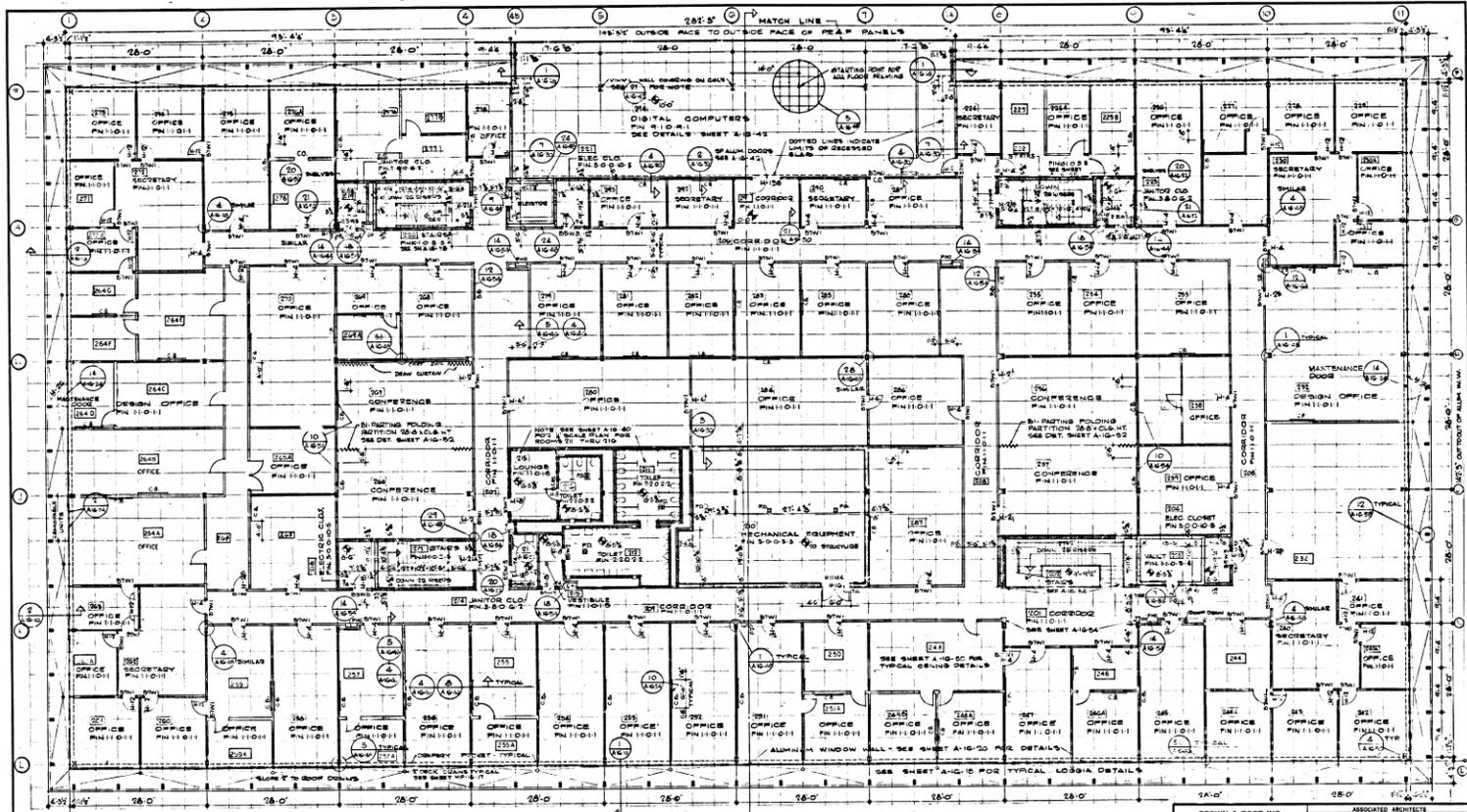
ASL -146



ASL -147



ASL -148



COLOR SCHEDULE OF PAINTED AND PRE-FINISHED MATERIALS - SEE KEY COLOR CHART DRAWING A-10-2

ROOMS OR AREAS	FLOOR	WALLS	CEILING	DOOR	DOOR CASE	WINDOW	WINDOW CASE	TRIM	MEASURES
OFFICES & SECRETARY	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
CONFERENCE	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
CONFERENCE ROOMS	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
DIGITAL COMPUTER	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
CONC & RESTROOMS	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
TOILETS	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
JANITOR CLOSETS	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
MECHANICAL ROOMS	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
ELECTRIC CLOSETS	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
VAULT	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
STAIRS	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
STAIRS 202	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"
REINFORCING FOUNDATION ALCOVE	BT	A	RT	D	C	B	AW	HW	1 1/2" x 3 1/2"

SECOND FLOOR PLAN - SOUTH
SCALE 1/8" = 1'-0"

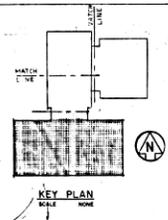
GENERAL NOTES:

- REFER TO SHEET A-10-2 FOR DOOR SCHEDULE
- REFER TO SHEETS A-10-20 & A-10-21 FOR INTERIOR DOOR & DOOR SWING DETAILS
- SEE SPECIFICATIONS FOR HARDWARE SCHEDULE
- REFER TO A-10-2 FOR SHOWN FROM SCHEDULE
- SEE SHEET A-10-20 FOR RENTHOUSE PLAN
- CEILING HEIGHT - 9'-0" UNLESS OTHERWISE SHOWN THEREIN
- REFER TO SHEET A-10-20 FOR LINTEL SCHEDULE & DOOR TO STAIR ENCLOSURE HAVE HORIZONTAL SBT

GRAPHIC SCALES

AS-BUILT

680 (NAS)-41-443-62-3



BROWN & ROOT INC.
HOUSTON, TEXAS

ASSOCIATED ARCHITECTS:
Brooks & Barr HOUSTON, TEXAS
Charles & Kammath HOUSTON, TEXAS
White Caloun HOUSTON, TEXAS
Tomate & Jackson HOUSTON, TEXAS
Consulting Mechanical Engineers
Bernard Johnson & Associates HOUSTON, TEXAS

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

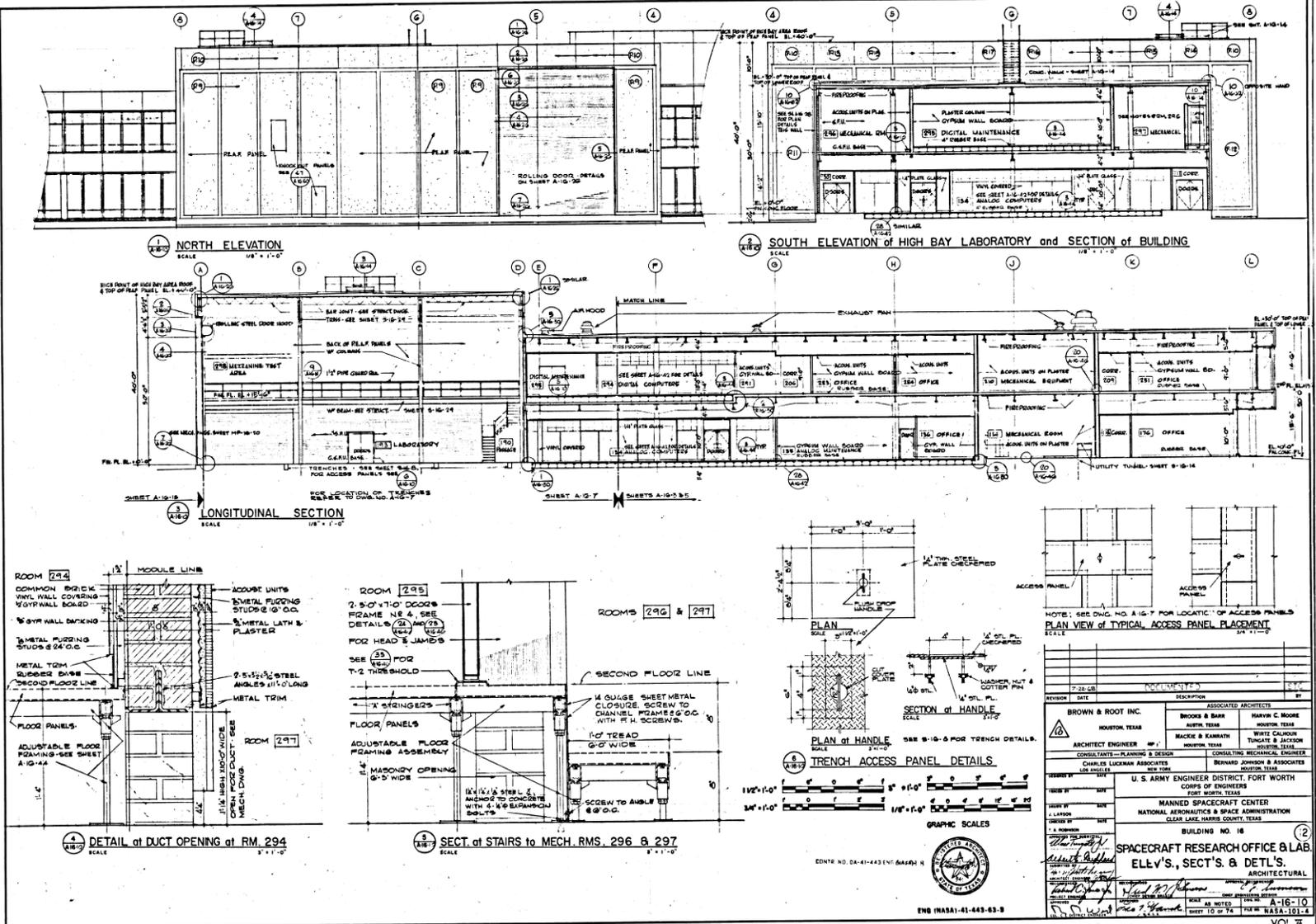
MANNED SPACECRAFT CENTER
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
CLEAR LAKE, HARRIS COUNTY, TEXAS

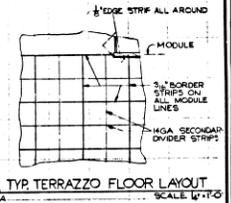
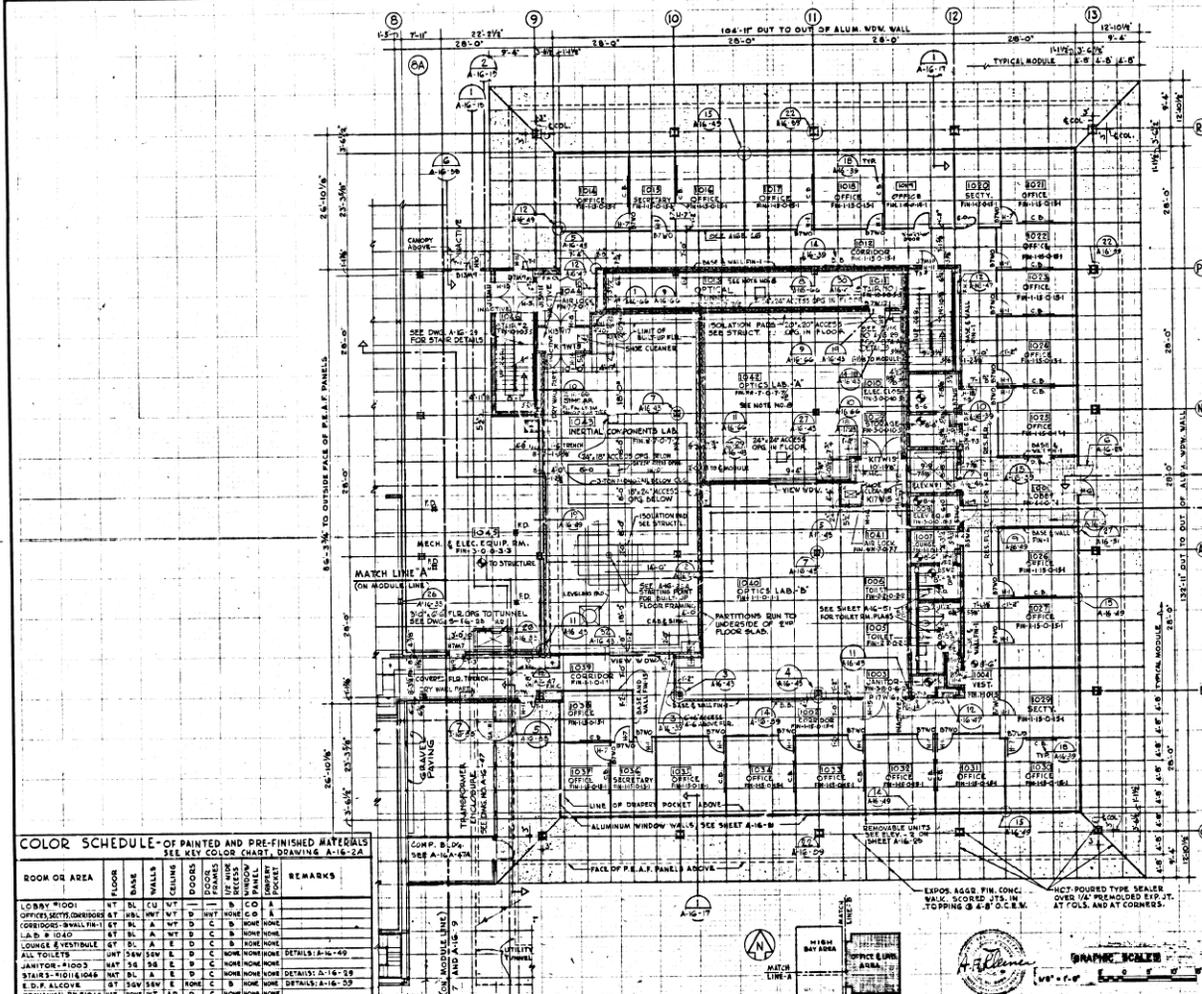
BUILDING NO. 16

SPACECRAFT RESEARCH OFFICE & LAB
2ND FLOOR PLAN - SOUTH
ARCHITECTURAL

DATE: 11/14/64
SCALE: 1/8" = 1'-0"
SHEET: 5 OF 74
PROJECT: NASA 101-4

VOL. 3





- GENERAL NOTES:**
- RESILIENT FLOORING CONTINUOUS UNDER ALL METAL STUD PARTITIONS & MOVABLE METAL PARTITIONS, UNLESS OTHERWISE NOTED.
 - CEILING HEIGHT IS 10'-0" UNLESS OTHERWISE SHOWN THUS 9'-6" E.T.R.
 - SEE SPECIFICATIONS FOR HARDWARE SCHEDULE.
 - REFER TO SHEET A-16-2 FOR ROOM FINISH SCHEDULE & DOOR SCHEDULE.
 - REFER TO SHEETS A-16-3 & A-16-25 FOR INTERIOR DOOR AND FRAME DETAILS, AND UNTEL SCHEDULE & LEGEND.
 - REFER TO SHEET A-16-49 FOR MOVABLE PARTITION DETAILS.
 - FOR LOCATION OF FLOOR DRAINS REFER TO DWG MP-16-41 & BLACK VINYL ASBESTOS TRANSITION STRIPS ARE ON EACH SIDE OF THE EXPANSION JOINTS IN ROOMS (D) & (E).

COLOR SCHEDULE - OF PAINTED AND PRE-FINISHED MATERIALS
SEE KEY COLOR CHART, DRAWING A-16-2A

ROOM OR AREA	FLOOR	WALLS	CEILING	DOORS	FRAMES	SELECTED PARTITION	REMARKS
LOBBY #1001	1	BL	CU	WT	WT	CO	A
OFFICES, MEETS, OVERLOCKS AT	1	BL	WT	WT	WT	CO	B
CORRIDORS - WALL FINISH	1	BL	A	D	C	B	1
LAB # 1040	1	BL	A	WT	B	C	1
LOUNGE & VESTIBULE	1	BL	A	D	C	B	1
ALL TOILETS	1	WT	WT	WT	WT	WT	1
STAIRS - #1016	1	BL	A	D	C	B	1
E. E. F. ELEVATOR	1	WT	WT	WT	WT	WT	1
MECHANICAL ROOMS	1	BL	A	D	C	B	1
ISOLATION LAB	1	BL	A	D	C	B	1
ISOLATION PASS	1	BL	A	D	C	B	1
ISOLATION LAB 'A'	1	BL	A	D	C	B	1
ISOLATION LAB 'B'	1	BL	A	D	C	B	1
ISOLATION LAB 'C'	1	BL	A	D	C	B	1
ISOLATION LAB 'D'	1	BL	A	D	C	B	1
ISOLATION LAB 'E'	1	BL	A	D	C	B	1
ISOLATION LAB 'F'	1	BL	A	D	C	B	1
ISOLATION LAB 'G'	1	BL	A	D	C	B	1
ISOLATION LAB 'H'	1	BL	A	D	C	B	1
ISOLATION LAB 'I'	1	BL	A	D	C	B	1
ISOLATION LAB 'J'	1	BL	A	D	C	B	1
ISOLATION LAB 'K'	1	BL	A	D	C	B	1
ISOLATION LAB 'L'	1	BL	A	D	C	B	1
ISOLATION LAB 'M'	1	BL	A	D	C	B	1
ISOLATION LAB 'N'	1	BL	A	D	C	B	1
ISOLATION LAB 'O'	1	BL	A	D	C	B	1
ISOLATION LAB 'P'	1	BL	A	D	C	B	1
ISOLATION LAB 'Q'	1	BL	A	D	C	B	1
ISOLATION LAB 'R'	1	BL	A	D	C	B	1
ISOLATION LAB 'S'	1	BL	A	D	C	B	1

FIRST FLOOR PLAN - EAST
SCALE 1/8" = 1'-0"

KEY PLAN
SCALE NONE

44
NOTATION: SEE DWG. (A-16-3) 41-441-64-8

THE LAMSON COMPANY
ARCHITECTS
1000 RAVENHURST DRIVE
ANN ARBOR, MICHIGAN 48106

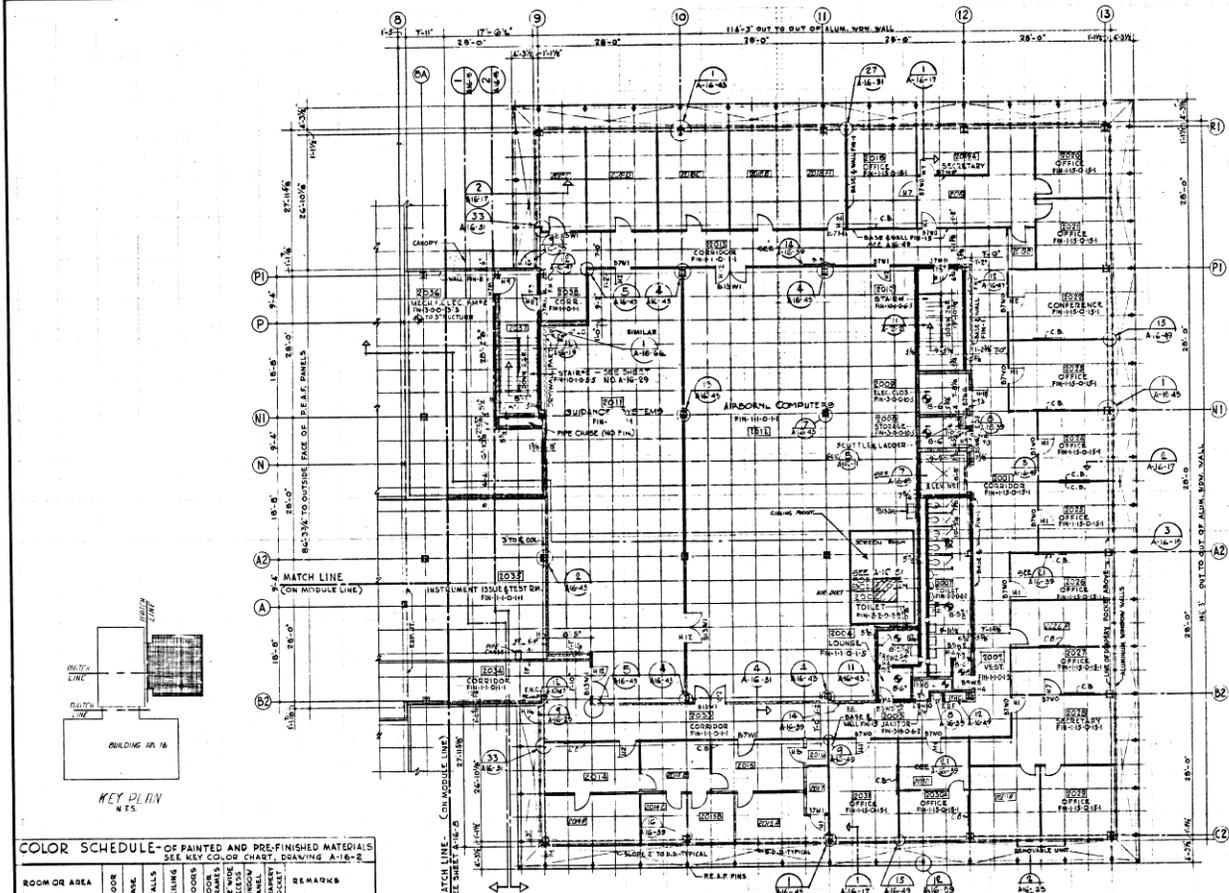
U. S. AIR FORCE
MILITARY DISTRICT
ANN ARBOR, MICHIGAN 48106

6

BUILDING NO. 18
SPACECRAFT RESEARCH OFF. & LAB.
SPACECRAFT CONTROL TECHNOLOGY LAB
FIRST FLOOR PLAN - EAST
ARCHITECTURAL

DATE: 11/17/60
BY: [Signature]
CHECKED: [Signature]
APPROVED: [Signature]

1/8" = 1'-0" DRAWING A-16-4



COLOR SCHEDULE - OF PAINTED AND PRE-FINISHED MATERIALS
SEE KEY COLOR CHART, DRAWINGS A-18-B

ROOM OR AREA	FLOOR	WALLS	CEILING	DOORS	TRIM	WOOD	GLASS	PAVING	REMARKS
OFFICES (S&TS, GOR, S&S)	GT	BL	WT	VT	D	WT	NONE	AW	A
FOYER/DOORS - SMALL FRI	GT	BL	WT	D	C	B	NONE	NONE	NONE
CORRIDOR #203A	GT	BL	A	VT	D	C	B	NONE	NONE
CONFERENCE RM. S	GT	BL	WT	D	WT	NONE	AW	A	BOLDING PART - COLOR FD
PROD. RM. & CLO. #2016	GT	BL	WT	D	WT	NONE	NONE	NONE	NONE
LOUNGE & VESTIBULE	GT	BL	A	VT	D	C	B	NONE	NONE
ALL TOILETS	UN	SSW	SSW	E	D	C	NONE	NONE	NONE
STAIRS #2013	ST	SS	SS	E	P	C	NONE	NONE	NONE
STAIRS #2016 & 2037	NAT	RL	A	VT	D	C	NONE	NONE	DETAILS:
E.D.P. ALCOVE	GT	SSW	SSW	E	D	C	NONE	NONE	DETAILS: A-16-BB
STAIRS #2008, #2009	NAT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2010	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2011	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2012	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2013	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2014	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2015	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2016	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2017	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2018	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2019	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2020	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2021	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2022	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2023	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2024	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2025	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2026	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2027	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2028	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2029	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2030	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2031	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2032	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2033	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2034	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2035	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2036	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2037	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2038	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2039	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2040	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2041	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2042	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2043	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2044	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2045	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2046	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2047	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2048	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2049	GT	BL	A	VT	D	C	NONE	NONE	NONE
STAIRS #2050	GT	BL	A	VT	D	C	NONE	NONE	NONE

- GENERAL NOTES:**
1. RESILIENT FLOORING CONTINUOUS UNDER ALL METAL STUD PARTITIONS & MOVABLE METAL PARTITIONS UNLESS OTHERWISE NOTED.
 2. CEILING HEIGHT IS 9'-0" UNLESS OTHERWISE SHOWN THUS: 8'-6" etc.
 3. SEE SPECIFICATIONS FOR HARDWARE SCHEDULE.
 4. REFER TO SHEET A-16-B FOR ROOM FINISH SCHEDULE & DOOR SCHEDULE.
 5. REFER TO SHEETS A-16-B1 & A-16-B2 FOR INTERIOR DOOR AND FRAME DETAILS, AND UNITS, SCHEDULE & LEGEND.
 6. REFER TO SHEET A-16-B3 FOR DETAILS OF MOVABLE METAL PARTITIONS.
 7. FOR LOCATION OF FLOOR DRAINS REFER TO DWG. WP-16-49.

INVESTIGATION NO. ENG. (6823) 41 443, 24-B

THE LAMSON COMPANY
1001 WEST 11TH STREET
DALLAS, TEXAS 75204

W. S. AMST ENGINEERS DISTRICT
1001 WEST 11TH STREET
DALLAS, TEXAS 75204

MAINTENANCE SPACECRAFT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CLEAR LAKE, HARRIS COUNTY, TEXAS

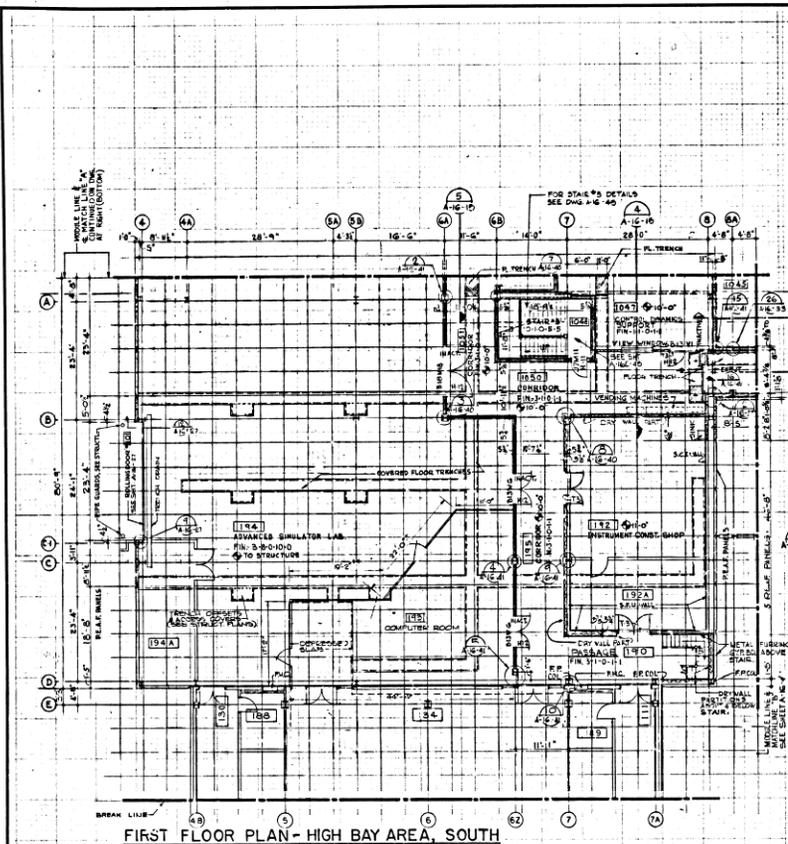
BUILDING NO. 16
SPACECRAFT RESEARCH OFF. & LAB.
SPACECRAFT CONTROL TECHNOLOGY LAB.
SECOND FLOOR PLAN - EAST
ARCHITECTURAL

DATE: 1/8/68
SCALE: 1/8" = 1'-0"

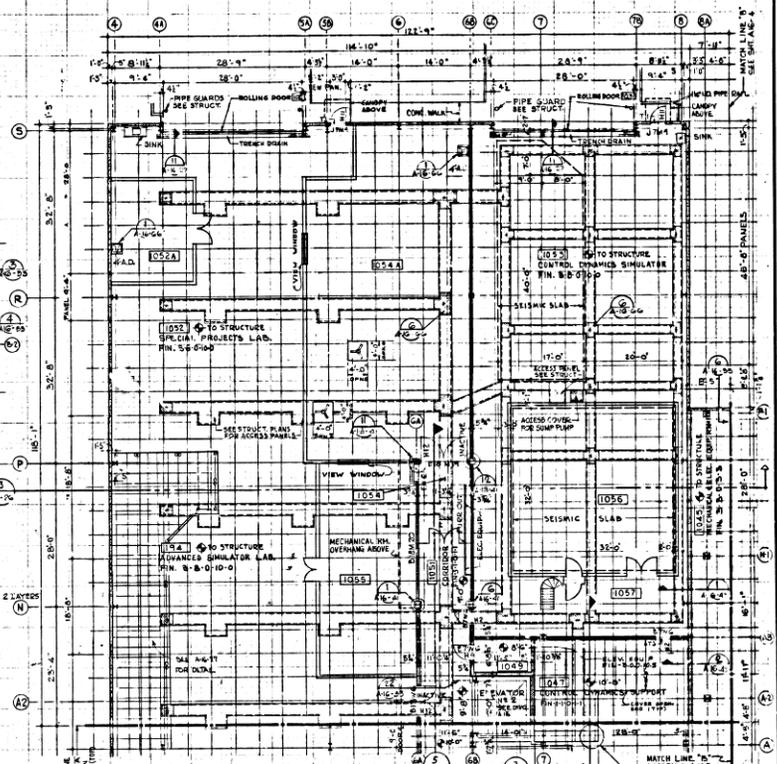
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ASL-155



FIRST FLOOR PLAN - HIGH BAY AREA, SOUTH
SCALE 1/8" = 1'-0"

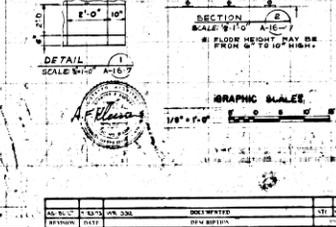


FIRST FLOOR PLAN - HIGH BAY AREA, NORTH
SCALE 1/8" = 1'-0"

COLOR SCHEDULE OF PAINTED AND PRE-FINISHED MATERIALS
SEE KEY COLOR CHART, DRAWING A-159-22

ROOM OR AREA	FLOOR	WALLS	CEILING	DOORS	STAIRS	ROOF	REMARKS
LAB AREAS 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200	BL	BL	WT	BL	BL	BL	SEE NOTE 107
RESTROOM 201-204	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 101	BL	BL	WT	BL	BL	BL	SEE NOTE 107
SPECIAL PROJECTS 102	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 103	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 104	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 105	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 106	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 107	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 108	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 109	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 110	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 111	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 112	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 113	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 114	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 115	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 116	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 117	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 118	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 119	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 120	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 121	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 122	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 123	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 124	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 125	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 126	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 127	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 128	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 130	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 131	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 132	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 133	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 134	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 135	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 136	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 137	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 138	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 139	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 140	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 141	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 142	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 148	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 155	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 156	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 158	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 167	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 168	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 169	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 170	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 171	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 177	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 178	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 180	BL	BL	WT	BL	BL	BL	SEE NOTE 107
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CONTROL DYNAMICS 184	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 185	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 186	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 187	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 188	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 189	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 190	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 191	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 192	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 193	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 194	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 195	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 196	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 197	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 198	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 199	BL	BL	WT	BL	BL	BL	SEE NOTE 107
CONTROL DYNAMICS 200	BL	BL	WT	BL	BL	BL	SEE NOTE 107

- GENERAL NOTES**
1. CEILING HEIGHTS SHOWN THUS: 10'-0" (ETC)
 2. SEE SPECIFICATIONS FOR HARDWARE SCHEDULE AND DOOR SCHEDULE.
 3. REFER TO SHEET A-16-2 FOR ROOM FINISH SCHEDULE AND DOOR SCHEDULE.
 4. REFER TO SHEETS A-16-51 & A-16-55 FOR INTERIOR DOOR AND FRAME DETAILS AND LINTIL SCHEDULE & LEGEND.
 5. REFER TO SHEET A-16-15 FOR DETAILS OF ROLL UP DOORS, MARKED 101, 102, 103, & 104.
 6. IN LAB. AREAS 103 & 104: INTERIOR FLOOR FINISH AND PART OF SOUTH EXTERIOR WALLS ARE EXPOSED P.E.A.R. PANELS.
 7. NON FLOOR DRAIN LOCATIONS SEE DWG. NO. MP-16-109.



INVITATION NO. ENG. INAS31-41-445-24-2

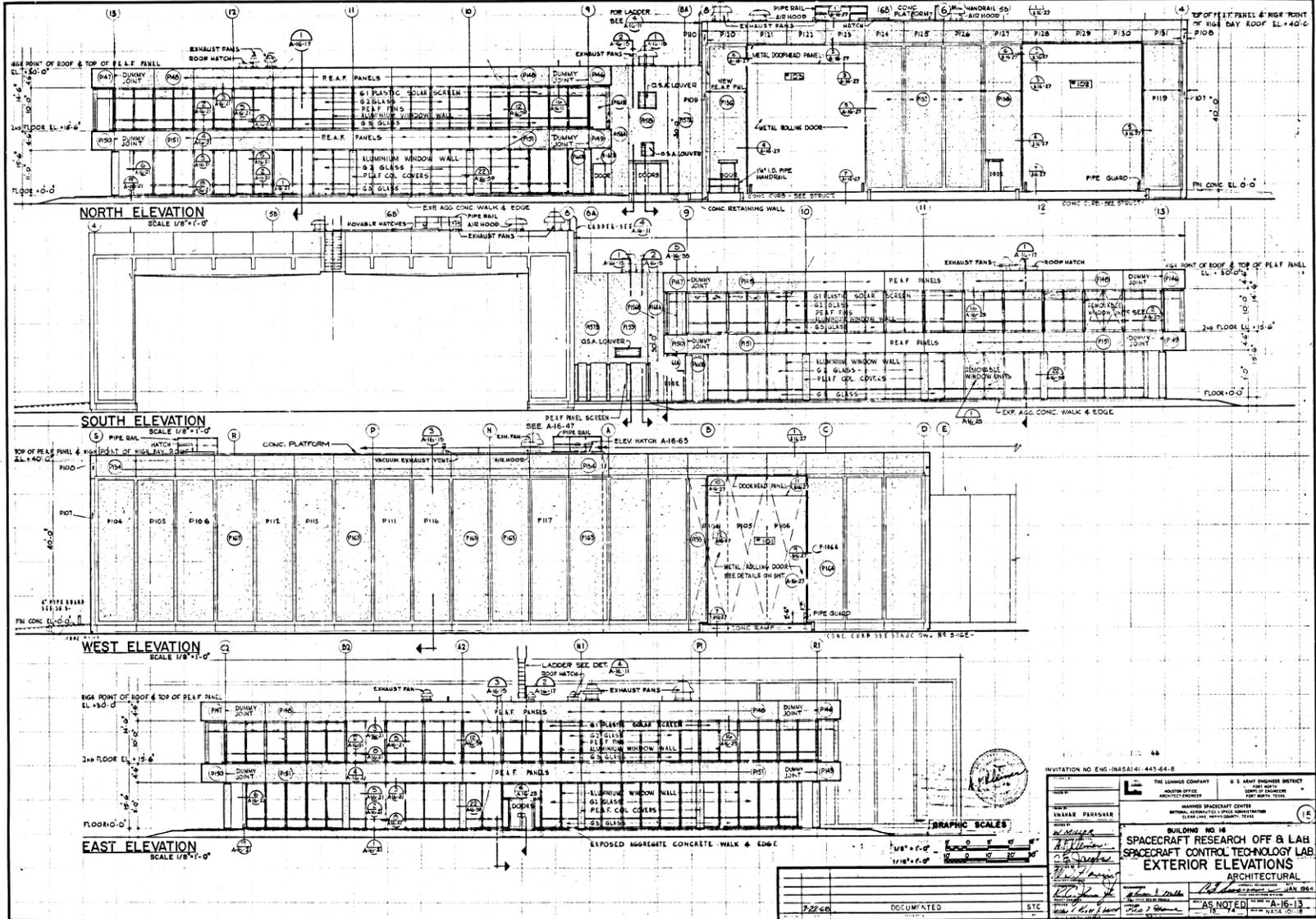
THE LOWMYER COMPANY
ARCHITECTS

6 S. ARMY AVENUE DISTRICT
OFFICE BUILDING
FORT WORTH, TEXAS

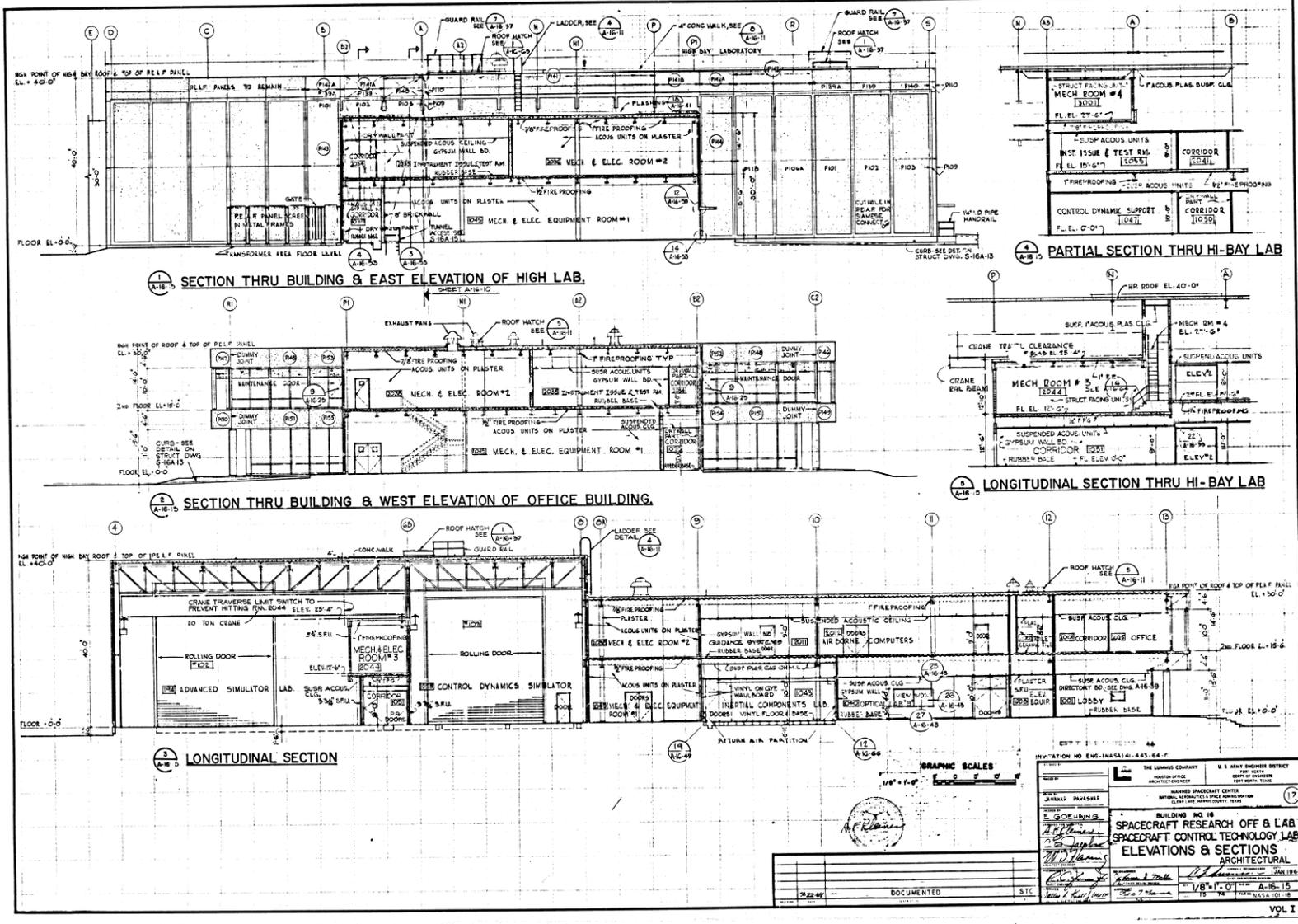
OWNER: SPACECRAFT RESEARCH CENTER
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
1200 AVENUE QUINCY, WASHINGTON, D.C.

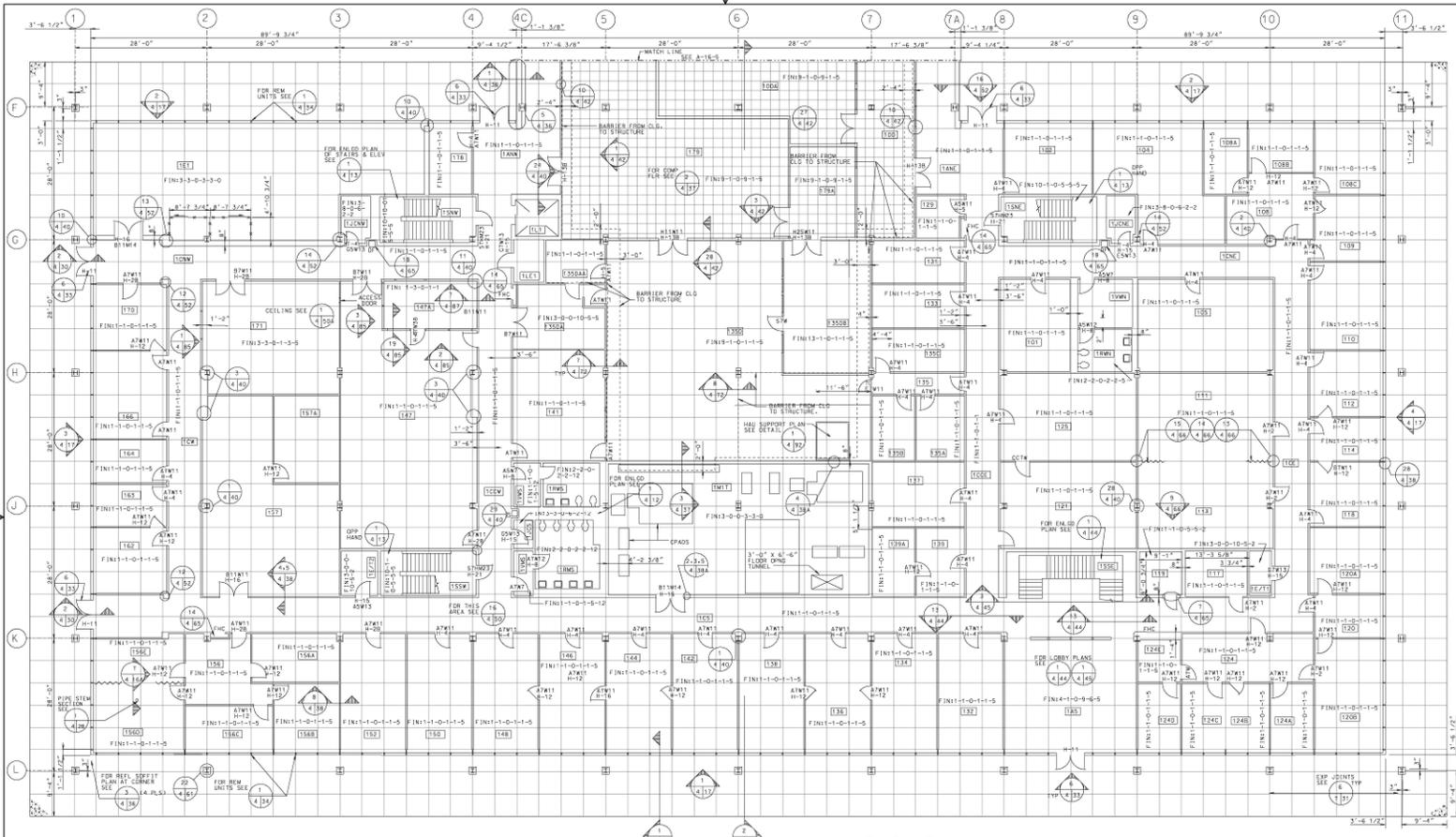
BUILDING NO. 18
SPACECRAFT RESEARCH OFF. B. LAB.
SPACECRAFT CONTROL TECHNOLOGY LAB
FIRST FLOOR PLAN - WEST
ARCHITECTURAL

DATE: 10/1/67
SCALE: 1/8" = 1'-0"



ASL-158

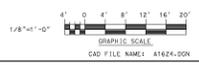
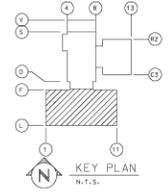




REVISED-06-08

1 4
 FIRST FLOOR PLAN (SOUTH)
 SCALE: 1/8" = 1'-0"

- GENERAL NOTES:
1. REFER TO SHEET A-16-01 FOR DOOR SCHEDULE.
 2. REFER TO SHEET A-16-04 FOR WINDOW SCHEDULE.
 3. REFER TO SHEET A-16-05 FOR INTERIOR DOOR & DOOR FRAME DETAILS.
 4. REFER TO A-16-05 FOR WINDOW FRAME DETAILS.
 5. REFER TO A-16-05 FOR WINDOW FINISH SCHEDULE.
 6. REFER TO SHEET A-16-02 FOR LIGHTING CONTROLS UNDER ALL.
 7. REFER TO SHEET A-16-02 FOR ALUMINUM WINDOW WALLS.



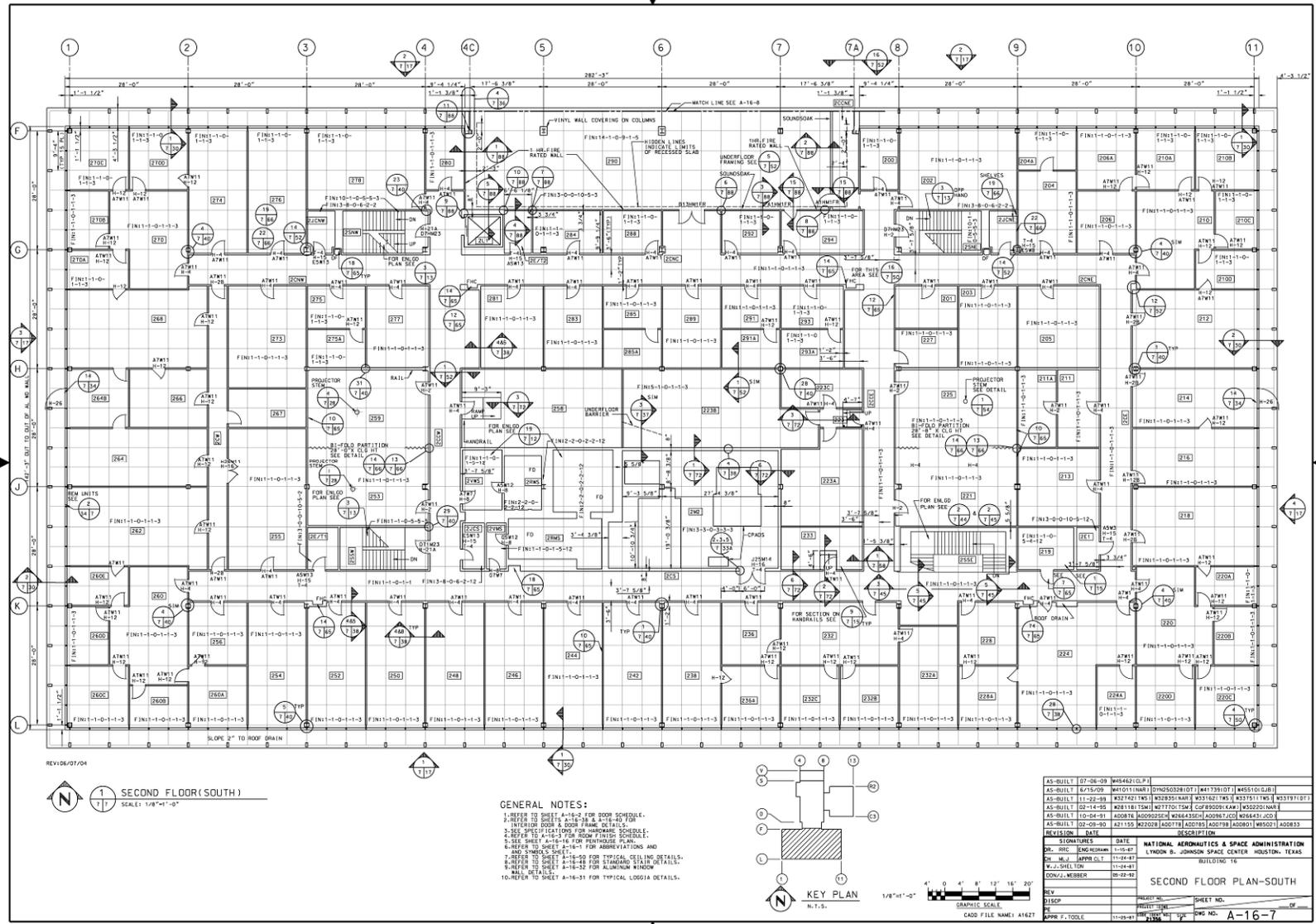
REVISION	DATE	DESCRIPTION
AS-BUILD	10/19/00	W46205(2,3)
AS-BUILD	09-23-00	W4108(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2)
AS-BUILD	11-14-00	W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2)
AS-BUILD	09-18-97	W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2)
AS-BUILD	07-22-95	W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2)
AS-BUILD	04-19-91	W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2) W4315(1,2)

REVISION	DATE	DESCRIPTION
DR. AM	10-7-00	NATIONAL AERONAUTICS & SPACE ADMINISTRATION
DR. AM	10-7-00	LYNDON B. JOHNSON SPACE CENTER
DR. AM	10-7-00	HOUSTON, TEXAS
DR. AM	10-7-00	BUILDING 16
DR. AM	10-7-00	11-00-01
DR. AM	10-7-00	11-00-01

REV	DATE	SHEET NO.	OF
REV	11-09-01	16	16
APPR	11-09-01	16	16

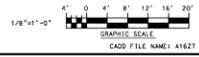
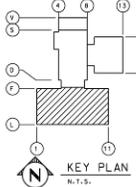
FIRST FLOOR PLAN (SOUTH)
 DWG NO. A-16-4

ASL-160



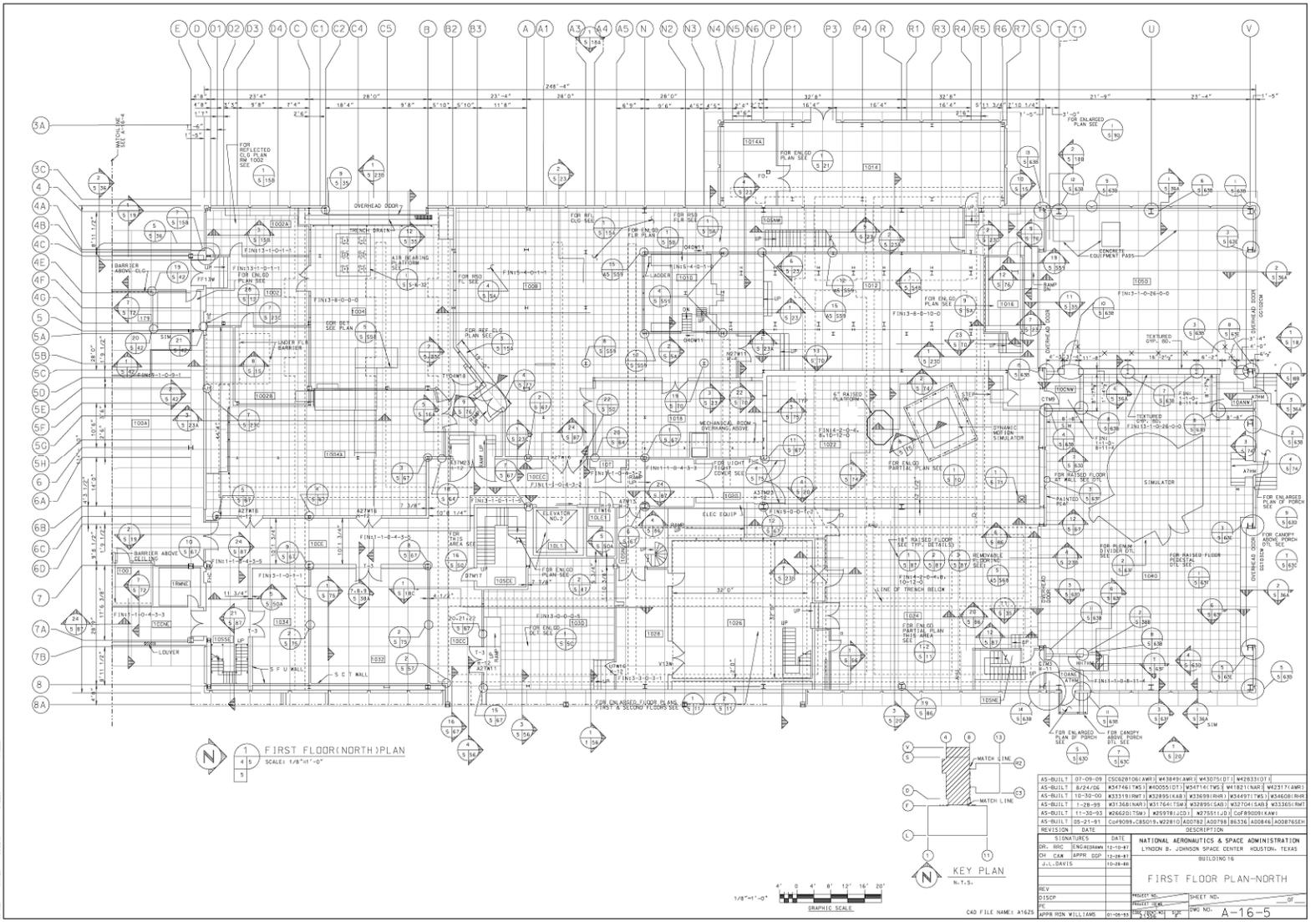
REV: 06/07/04
 SECOND FLOOR (SOUTH)
 SCALE: 1/8"=1'-0"

- GENERAL NOTES:**
1. REFER TO SHEET A-16-2 FOR DOOR SCHEDULE.
 2. REFER TO SHEET A-16-3 FOR INTERIOR DOOR & DOOR FRAME DETAILS.
 3. SEE SPECIFICATIONS FOR HINGE SCHEDULE.
 4. REFER TO A-16-3 FOR ROOM FINISH SCHEDULE.
 5. SEE SHEET A-16-4 FOR TEXTURE PLAN.
 6. REFER TO SHEET A-16-1 FOR ABBREVIATIONS AND A-16-2 FOR FINISH SCHEDULE.
 7. REFER TO SHEET A-16-4 FOR TYPICAL CEILING DETAILS.
 8. REFER TO SHEET A-16-4 FOR STANDARD STAIR DETAILS.
 9. REFER TO SHEET A-16-2 FOR ALUMINUM WINDOW DETAILS.
 10. REFER TO SHEET A-16-31 FOR TYPICAL LOGGIA DETAILS.

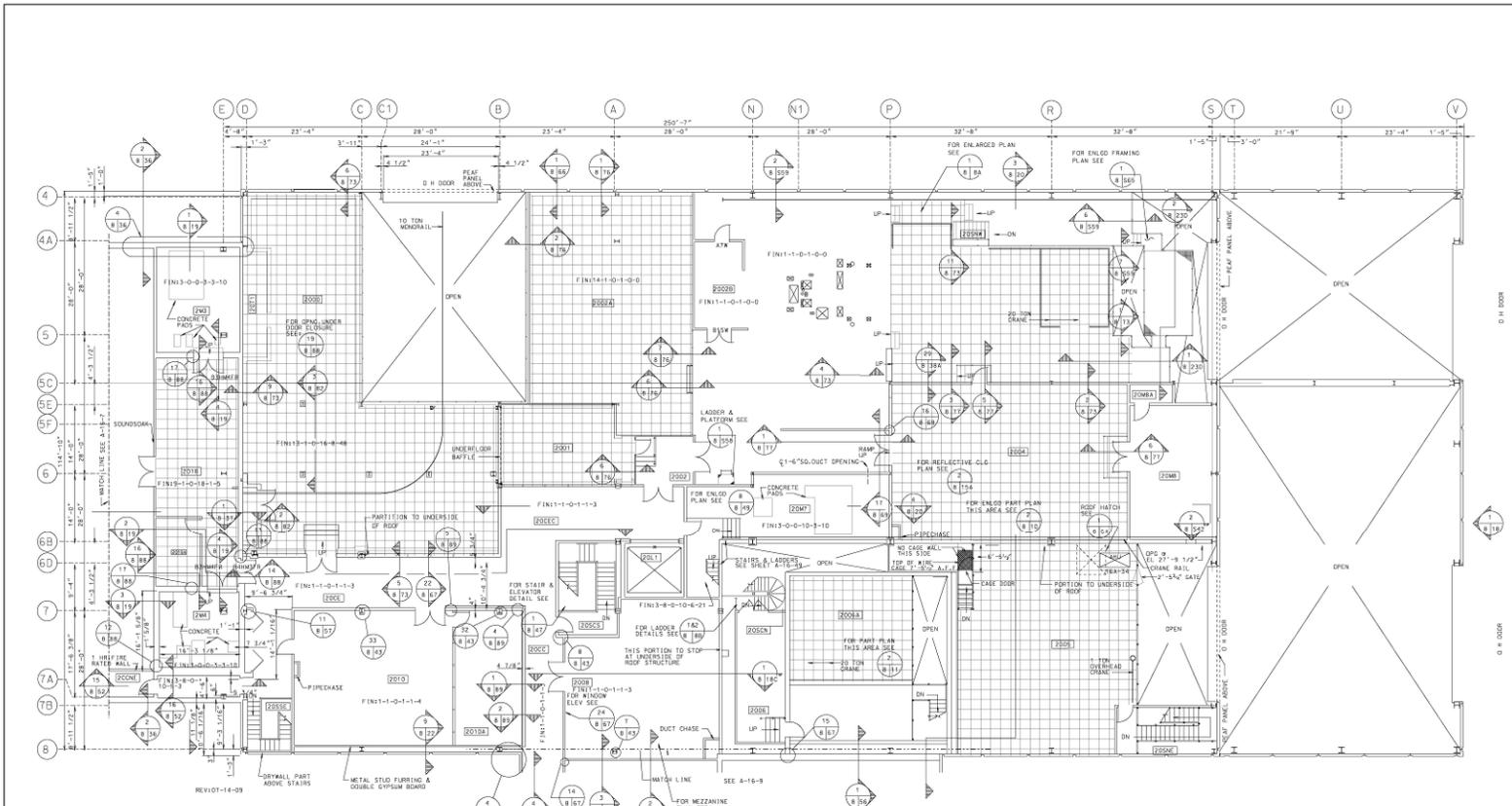


AS-BUILD	07-08-09	M46421(2,F)			
AS-BUILD	04-10-09	M47101(N)	07M50328(10)	M47351(10)	M55101(10)
AS-BUILD	11-22-09	M327421(1)	M28351(NAR)	M331621(1)	M331711(1)
AS-BUILD	02-14-05	M28181(1)	M27701(1)	M27701(1)	M27701(1)
AS-BUILD	10-08-01	A00076	M000000000	M000000000	M000000000
AS-BUILD	02-09-00	A21155	M20000	A00118	A00119
REVISION	DATE	DATE	DESCRIPTION		
DR	ERIC	ENGINEER	NATIONAL AERONAUTICS & SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER INDUSTRIAL, TEXAS		
DR	M.J. JAPPEL	DR	BUILDING 16		
			P.J. SHELLTON		
			DON J. WEBBER		
REV	DATE	SHEET NO.	DRAWING NO.		
DR	11-24-01	11	A-16-7		
DR	09-22-02	11	A-16-7		
DR	11-09-01	11	A-16-7		

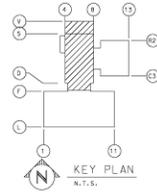
ASL-161



ASL-162



SECOND FLOOR (NORTH)
SCALE: 1/8"=1'-0"



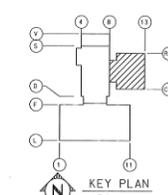
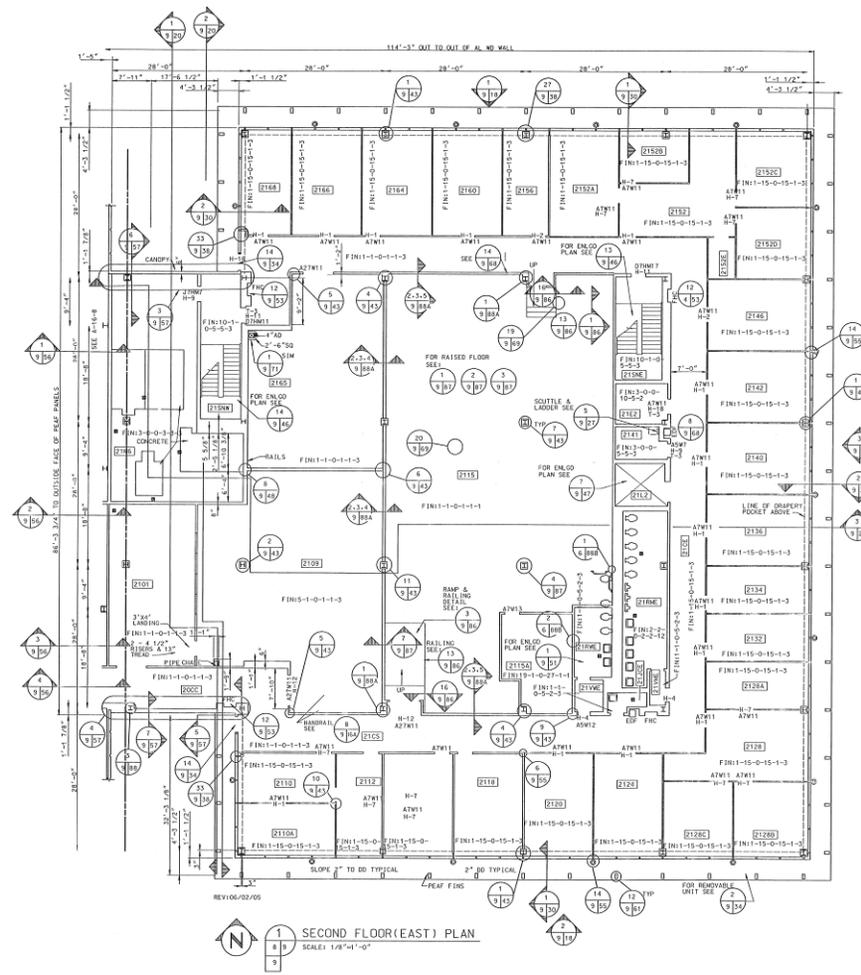
KEY PLAN
N.T.S.
GRAPHIC SCALE
CAD FILE NAME: A162B.DGN

AS-BUILD	08-09-09	W54621977			
AS-BUILD	03-29-09	W537621961	W338761968	W44561071	W42231071
AS-BUILD	02-23-09	W28610103	W4992001	W183301036A	W328261968
AS-BUILD	03-10-02	W08798	W24800	W08801	W2159
AS-BUILD	08-08-05	W071987	W00751	W00752	W00753
AS-BUILD	02-17-88	C1084	W1132	W12457	W15445

REVISION	DATE	DESCRIPTION
DR. BHC	ENGINEER	1-15-07
CH. M.J.	APPR. EIT	11-04-07
M.-J. SHELTON		11-04-07

STRUCTURES		DATE		NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
				LYNDON B. JOHNSON SPACE CENTER HOUSTON, TEXAS	
				BUILDING 16	
				SECOND FLOOR PLAN - NORTH	
REV		PROPERTY		SHEET NO.	OF
D/ISCP		PROJECT			
APPR. 7-TOOLE	11-29-07	DATE	11-29-07	DWG NO.	A-16-8

ASL-163



NOTES:
 1. BUILDING FLOORINGS CONTINUED UNDER ALL METAL STUD FING & MOVABLE METAL FING SPACES DIMENSIONS NOTED.
 2. REFER TO ALL BUNDLE FOR THE MOVABLE PARTITION ELEV.
 3. REFER TO SHEET A-16-38 & A-16-39 FOR DOOR SCHEDULES & SCHEDULES.
 4. REFER TO SHEET A-16-38 & A-16-39 FOR INTERIOR DOOR AND FRAME.
 5. REFER TO SHEET A-16-95 FOR DETAILS OF MOVABLE METAL PARTITION.
 6. FOR LOCATION OF FLOOR DRIVING REFER TO DWG MP-16E-05.

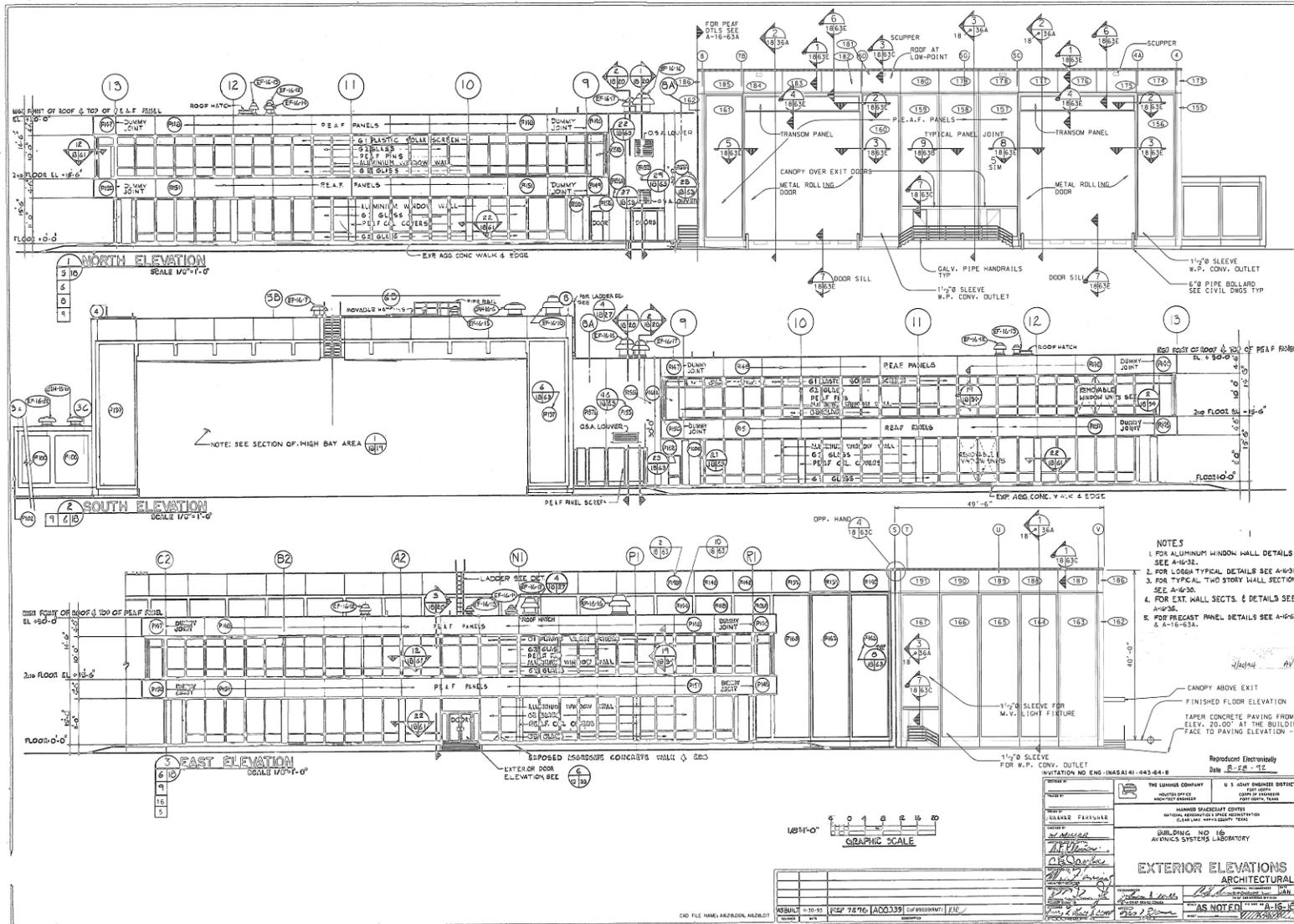
1 SECOND FLOOR (EAST) PLAN
 SCALE: 1/8"=1'-0"



APPROVED
 [Signature]
 11-24-87

AS-BUILD	11-29-06	W1182107	N118181(NAR)
AS-BUILD	10-10-97	COP47005	M27007(NMT) C0F89009(NMT) M20251(FSM) M23286(SAS)
AS-BUILD	10-03-90	COP0000	CP0000(COPY) A00001 A00002 B00003 B00004 B00005 B00006 B00007
AS-BUILD	11-01-88	W02254	W10083 A00033 W14236 A00032 W17500 M19288 A00055
AS-BUILD	09-12-79	W02262	1600 0354 J148 J218 MCP2726 M0992 B431 W08003
REVISION	DATE	DESCRIPTION	
SIGNATURES			
DR.	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
W.J. SHELTON	11-24-87	LYNDON B. JOHNSON SPACE CENTER HOUSTON, TEXAS	
AERONAUTICS SYSTEMS LABORATORY			
SECOND FLOOR PLAN-EAST			
REV	DATE	PROJECT NO.	SHEET NO.
1	11-24-87	1182107	11
APP'R	DATE	DRG. NO.	A-16-9

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